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NOTES AND COMMENTS.

Oxygen in Cast-Iron.

Of all the physical phenomena exhibited by cast irons, probably none has so exercised the minds of scientific and practical men alike as the fact that irons of apparently the same chemical composition, as determined by ordinary analysis, have different qualities, structure, strength, etc., and that these qualities are preserved on remelting and reappear in castings of which the irons form an important ingredient. The explanation cannot be found in the rarer elements, such as nickel, cobalt, chromium, titanium, vanadium and the like, as has been proved by a great deal of experimental evidence, and various other theories have been put forward at different times. The most convincing of these, so far, has been to the effect that the form of the graphitic carbon (the final condition of which is so definitely associated with the variation in physical properties) is largely affected by the conditions under which the iron was made in the blast furnace. As we have previously pointed out, this contention implies that molten iron from the cupola does not contain all its constituents in absolute chemical solution, but that something in the nature of mechanical suspension of certain forms of graphite occurs and allows that graphite to retain its individual characteristics, which are accordingly reproduced in the re-cast metal. Metallurgists generally, however, have fought somewhat shy of any theory involving allotropic modifications of graphitic carbon, and with a few exceptions have sought an explanation elsewhere. This position may not appear quite logical in view of the known allotropic forms of carbon; but it is perhaps just as reasonable to acknowledge other chemical explanations, since ordinary chemical analysis (by which two irons would be determined as being of the same composition) is admittedly imperfect.

In this connection considerable interest surrounds the contentions recently put forward in a Paper before the American Institute of Mining Engineers by Mr. J. E. Johnson, jun., and which is given in abstract on another page. It appeared to the author inconceivable that a quality which would survive remelting and superheating to a point well above the fusion point, as in foundry practice, should be a purely physical quality—that if one iron were better than another because cast at a lower temperature, for instance, and for no other reason (both being identical in analysis), when both were remelted to the same temperature and recast under the same conditions, it was incredible that they would not lose the difference in quality due to this difference in original casting temperature. As the difference in quality evidently did persist in spite of re-melting, it was concluded that the difference was a chemical one.

The fact that re-melting does not destroy the difference in question might appear conclusively in favour of the author's contentions as regards a chemical explanation; but on this question there are other possibilities to be considered. It has hitherto been generally assumed that all carbon in molten iron exists in solution, despite the condition of the graphite in the prior solid metal; but in some quar-

ters that belief is now held in question, and the suggestion is put forward that the mere melting of iron does not necessarily dissolve all the graphite if the latter exists in certain forms, but may leave it partly undissolved to resume its characteristics on cooling. This suggestion is by no means proven, but it merits consideration, and on that account Mr. Johnson's assumption that a physical explanation is ruled out by the persistence of the characteristic despite re-melting does not necessarily stand accepted. To refute the possibility of a physical explanation it would be necessary to take two irons of the same analysis but of different physical characteristics and raise them under the same conditions to a temperature at which the most refractory form of graphite would dissolve in the metal. Ordinary re-melting has not yet been proved to do this with irons containing a large proportion of large-flaked refractory graphite.

Taking next the tests made by Mr. Johnson, he claims to have proved:—(1) That strong tough irons of high chilling qualities contain oxygen in appreciable quantities, while weaker irons of similar analysis contain less or no oxygen; (2) that poor and normal irons may be improved beyond recognition by introducing oxygen into them. We are prepared to accept tentatively the first conclusion, but the second certainly calls for a verdict of "unproven." The author distinctly states that he endeavoured to introduce oxygen into the hearth of the furnace in order to make a good iron, first by causing irregular working of the furnace, and then by introducing mill scale into the hearth just before cast time, but with little or no result, such as there was being rather detrimental. Also, by heating iron ore and other kinds of oxides in the bottom of a ladle and running iron in on them, stirring up the mixture and pouring test bars and sample pigs, though the grain of the iron was closed, no improvement in strength and toughness was observed. So far as the tests quoted are concerned, the only improvement appears to have resulted when introducing into the mixture irons which had special physical characteristics and also contained appreciable amounts of oxygen; but whether the physical characteristics imparted to the mixture were essentially associated with the oxygen or were incidentally accompanied by oxygen appears so far undetermined.

At this point another feature of the experiments calls for attention. In order to prove the oxygen theory, experiments were made to determine the effect of deoxidising some of these strong irons with recognised agents used for that purpose, and it was found that the deoxidised irons were greatly weakened. Even if the close-grained structure did not persist, as would be inferred from the author's later conclusion, an advocate of another theory might claim that the reaction produced by deoxidising altered the balance of heat conditions and reproduced to some extent those conditions under which large refractory graphite is formed. Nevertheless, the author has a strong point in support of his contention, in that deoxidised irons were weakened in the process.

While we are quite open to conviction on the influence of oxygen, it appears that all the author has succeeded in proving is that iron possessing certain characteristics has a comparatively high oxygen content. Whether the two facts are essentially associated, or whether the conditions producing the characteristics in question lead incidentally to a high oxygen content is still an open question. We understand that since the completion of the Paper, Mr. Johnson has made some successful experiments with the object of converting ordinary coke iron into iron of a grade equal or superior to charcoal iron. He claims to have treated 1 per cent. silicon iron so as to introduce oxygen into it, with resulting remarkable improvement in strength. We await with interest further details, as they may clear some of the foregoing doubtful points and establish the virtue of an element which has long been regarded as the founder's *bête noir*.

Nomenclature of Alloys.

To those who are familiar with the interesting but sadly misleading method at present in vogue of naming alloys, particularly of the non-ferrous metals, the efforts of the Institute of Metals Committee should strongly appeal. The present report may not at first strike one as being a very comprehensive production, but in view of the difficulties involved and the prejudices to be broken down, we may be thankful if it receives half the attention it deserves. After all, it embodies the principles, and any further report can only be an extension and adaptation of those principles. In brief these are as follows:—(1) Where an alloy consists of more than three metals its systematic name shall not as a rule contain more than the names of three metals present in the largest proportion by weight, but the presence of additional metals or elements shall be denoted by the prefix "comp." or "complex." If, however, an alloy of this kind contains an intentionally added element which, although present in small quantity, gives the alloy a distinctive character, that element may be named first. (2) In the systematic names reference should be made to all elements whose presence in the alloys in notable quantities is *intentional*. (3) With regard to alloys which contain two or more metals in equal or nearly equal quantities, where no numerical preponderance is established the metals should be placed in alphabetical order. Further, well-known and widely-used terms will be defined simply as definite abbreviations or contractions for certain names or groups of names in the systematic nomenclature. There appears no reason why these principles should not, with the sympathetic co-operation of the trade and commercial circles concerned, be developed to meet all the requirements likely to arise. The necessity for systematic nomenclature will scarcely be questioned, and that necessity will not diminish in the future, for the increasing application of the rarer elements in non-ferrous metallurgy must inevitably lead to serious confusion of ideas as to the respective values of alloys used in engineering.

British Foundrymen's Association: Birmingham Branch.

The annual meeting of the Birmingham Branch of the British Foundrymen's Association was held on Saturday, March 28, at the Birmingham Municipal Technical School. Mr. H. L. Reason proposed the re-election of Mr. C. Heggie as President of the Branch, reminding the members of the excellent work which Mr. Heggie had done for the Branch for many years past, especially in the office of Secretary. The proposition was seconded by Mr. J. Bullock, and carried unanimously. The re-election of Mr. H. Pemberton (Derby) as Senior Vice-President was proposed, but Mr. Pemberton asked to be excused on account of his engagements during the coming year. On the motion of Mr. R. Buchanan, Mr. D. Dalrymple was elected to the office, and Mr J. Shaw was elected the Junior Vice-President. The Branch Council was completed as follows:—Messrs. R. Buchanan, T. Baugh, J. Bullock, J. J. Howell, F. E. Robinson, H. L. Reason, J. H. Toy, H. Winterton, A. Harley, C. B. Roe, P. L. Bayliss, C. B. Pugh, and H. Mather. Mr. C. Grindlay was re elected Hon. Secretary and Mr. Mace was elected Auditor.

The Early History of Ironfounding.*

By Henry B. Wheatley, D.C.L., F.S.A.

(*Continued from page* 144.)

PART II.

Charcoal Ironworks in the Midlands, West and North of England, Wales, Scotland and Ireland.

England.

Cheshire.—Mentioned in Domesday Book.

Cumberland.—A grant of the forge at Winefel was obtained by the monks of Holm Cultram Abbey in the 12th century.

Durham.—Ironworks were founded during the Roman occupation in this country.

Gloucestershire.—Forest of Dean. These ironworks are situated about 12 or 16 miles west of Gloucester, and it is proved that they were founded by the Romans, as coins of Trajan, Antoninus Pius, and other emperors, have been found among the vast cinder-heaps in the district. Little history of these works, however, is recorded until the year 1188, when Giraldus Cambrensis refers to the noble forest of Dean which amply supplied Gloucester with iron and venison. Henry II. endowed the recently-founded abbey at Flaxley with a grant of two oaks out of the forest every seven days for supplying their iron forges with fuel. In the Patent Rolls of Henry III. (1237) there is a heading, "De forgiis levandis in Foresta de Deane," and in a judicial inquiry held in Gloucester Castle (1282) upwards of 72 "forgiæ errantes" are referred to as at work in the forest.

The Crown charged for licensing these movable forges at the rate of 7s. a year—viz., 3s. 6d. for six months, or 1s. 9d. a quarter. A miner received one penny or the worth of it in ore for each load of ore brought to any of the king's ironworks; but if conveyed out of the forest the penny was paid to the Crown.

Mushet supposes that iron was cast here in 1540, and he says the oldest piece of cast iron he ever saw bore the initials "E.R.," and the date 1555. The works were busy during the Commonwealth in making cannon and shot, but in 1674 there was a great decay in the works, and from the report of a Parliamentary Committee sitting in 1788 we learn that no regular work was carried on In 1795, however, there was a resumption of the iron manufacture.

Edward the Confessor demanded an annual amount of iron from the citizens of Gloucester. Camden affirms that in and before the reign of William the Conqueror the chief trade of the city was the forging of iron. This is mentioned in Domesday Book.

Herefordshire.—Iron worked in the Roman period mentioned in Domesday Book.

Lancashire.—In 1563 a royal decree was issued abolishing the bloomeries or iron smithies in Furness in Lancashire, in compliance with a petition of the inhabitants, because "they consumed all the loppings and croppings of the sole winter food for their cattle" (*Swank.*) It has been suggested that Furness is supposed to have derived its name "from the many furnaces therein of old time." In the Ulverston district iron was worked in the twelfth century.

Leicestershire.—Iron worked at Ashby-de-la-Zouch in 1643.

Lincolnshire.—Mentioned in Domesday Book.

Monmouthshire.—One of the streets of Monmouth is named Cinderhill. The ironworks at Tintern were of considerable antiquity, and they continued until 1828, three years after the Ashburnham furnace in Sussex was closed down. "Nearly the last operation that took place at Tintern occurred about the year 1828, just prior to its final extinction. Mr. David Mushet was desirous of trying some practical experiment in the smelting of 'wootz,' or Indian iron, and regarded the contemplated abandonment of the old blast furnace at Tintern a favourable opportunity of doing so. Its usual 'make' when in full operation was from 28 to 30 tons per week of charcoal forge pig-iron; and at that rate of production consumed 40 dozen sacks of charcoal, consisting of twelve sacks each, and assumed to consist of twelve bushels. It thus appears that in the production of one ton of pigs sixteen sacks of charcoal were consumed. This is stated by Mr. Mushet to have been the first charcoal furnace in the county that was blown with air compressed in iron cylinders, and against the employment of which a great prejudice was always entertained by the workmen."†

Nottinghamshire.—Cinder Hill, a village three miles north of Nottingham.

Somersetshire.—Mentioned in Domesday Book. Bath (Aquæ Solis) is said to have been the great arsenal of the Roman armies in Britain.

Staffordshire.—Ironfoundries were in operation here prior to the reign of Elizabeth, but the product was on a small scale until after the close of the 16th century. ("Journ. Arch Assoc.," XXIX., 174.) Plot's "Staffordshire" contains a chapter (IV.) on the iron ores of the county, with references to bloomeries.

Warwickshire. — Aston furnace (Birmingham), Forest of Arden.

Worcestershire.—Ironworks during the Roman occupation. Pensnett, Lord Dudley's ironworks.

Yorkshire.—Hunter refers to "the fact that in the midst of a mass of scoriæ, the refuse of some ancient bloomery near Bradford, a deposit of Roman coins was found." Extensive ironworks were established at Kimberworth by the monks of Kirkstead in 1160. Thoresby's "Leeds" contains references to ironworks, and mention is made of a place named Kirkby Overblows, near Harrogate.

Wales.

Glamorganshire.—Sussex ironmasters in Henry VIII.'s reign started ironworks in this county. ("Sussex Ironmasters in Glamorganshire," by W. Llewellin.—"Archæologia Cambrensis," 1863, Vol. IX. p. 81.)

Brecknockshire.—Large quantities of scoriæ supposed to be of Roman origin have been found at Crickhowell. Blast furnaces were built by Capel Hanbury in 1565 at Pontypool to smelt the Roman cinder. The Hanburys are said to have built ironworks at Llanelly about 1620. In 1770 the first coke furnace in South Wales was built at Cyfarthfa, and in 1788 there were six coke furnaces in South Wales.

* From a Paper read before the Royal Society of Arts and printed in the "Journal" of the Society.

† "Some Account of the Iron and Wire Works of Tintern," by William Llewellin.—"Archæologia Cambrensis," 1863, Vol. IX., p. 291.

Scotland.

Mr. Ivison Macadam, in his Paper on "The Iron Industry in Scotland," writes: "The slag heaps are widely distributed throughout Scotland, and their positions vary, but they can be roughly classified as—(1) on elevated positions on hillsides; (2) in valleys without water; (3) on the sides of streams; (4) near the sea." From the character of the cinders found in these various sites Mr. Macadam draws the following deductions: "That in the case of the works on the hillsides, the fuel and ore were roasted without the aid of an artificial blast. In support of this theory it is found that such sites are more numerous on such spots as are exposed to the influence of the prevailing winds. In the works situated in hollows the rush of wind through the confined space was made use of, or in the second variety of slag from this class of situation bellows were used. The third class were undoubtedly constructed to use an artificial blast of air obtained by the aid of water, and the fourth class most possibly employed a water-wheel, such as was used in early times in the Forest of Dean." The analysis of the slag has shown how wasteful was the process of manufacture adopted.

Mr. Macadam has compiled a list of a large number of sites of old ironworks arranged in counties. The fuel used was either wood charcoal or peat charcoal, and there is no evidence that coal was used in Scotland for iron manufacture until the Carron Works took it up somewhere after 1760. Mr. Macadam says that in 1607 Sir George Hay started his large ironworks at Letterawa, Loch Maree, in Ross-shire, which were worked by a colony of Englishmen. The district round Loch Maree gradually "became a veritable iron forge for the whole of England." "After the Rebellion of 1715 the Highlands were placed under military regulation, and an opening was presented for English enterprise. No scruples were then expressed as to the waste of timber, and the Scottish forests were extensively used for the conversion of English ore. The ore, being heavy and compact, was more easily transported to the wood than the timber to the ore."*

At the Carron Ironworks, a mile from Falkirk, the first blast-furnace was built in 1759. It was operated at first with charcoal, but later coke was substituted, and it was the first furnace in Scotland to use the new fuel.

In 1788 there were six coke furnaces in Scotland, and two charcoal furnaces of Bunawe and Goatfield. These charcoal furnaces were only blown out a few years ago.

Ireland.

The manufacture of iron was extensively fostered by the English in the reigns of Elizabeth and James I., but in the Rebellion of 1641 many of the works were closed. Sir William Petty established in 1660 and subsequent years many ironworks in the county of Kerry, which were continued until the middle of the 18th century, when they were stopped in consequence of the scarcity of timber. Petty stated in 1672 that 1,000 tons of iron were made in Ireland.

Statistics of Charcoal Iron Production.

1607.—We are told in John Norden's "Surveyor's Dialogue" that "there are or lately were in Sussex neere 140 hammers and furnaces for iron," and that "each of them spends in every twenty-four hours two, three or four loades of charcoale, which in a year amounteth to an infinite quantitie."

1719.—Macpherson asserts that at this time the ironworks of England employed 200,000 persons, and the consequent destruction of woods in Warwick, Stafford, Hereford, Monmouth, Gloucester, and Salop, was "not to be imagined." Over 20,000 tons of iron were imported, in addition to the amount produced in this country.

1725.—A pamphlet in the library of the British Museum, entitled "Interest of Great Britain in supplying himself with Iron impartially considered," was reprinted by the Iron and Steel Institute as an appendix to its "Journal" (1885, No. 2). It is undated, but is supposed to have been published about 1725. There is a list of forges in England and Wales, with figures of the annual output as follows:—*Sussex*—Bivelham, 40 tons; Hawkesden, 40; Brighlin, 40; Burwash, 40; Westfield, 40; Marshfield, 60; and Woodcock, 40. *Hampshire*—Sowley, 50 tons; Titchfield, 100; have made previously 200 tons. *Surrey and Kent*—Touchley, 50 tons; Barden, 40. Forges in other parts of the country show larger figures. The total is given as 12,190 tons, or a decrease of 7,295 from what had previously been produced. There is a printed note to this effect: "The making of British iron hath gradually decreased in proportion to the increase of the importation of foreign."

1737.—Macpherson states that 20,000 tons of foreign iron were imported (15,000 from Sweden, and the greater portion of the remaining 5,000 from Russia). The exports of wrought iron amounted to 3,000 to 3,500 tons per annum.

1740.—The number of furnaces in the country at this time is given as 59, producing 17,350 tons, as follows:—

		Tons			Tons.
Brecon ..	.. 2	600	Kent ..	.. 4	400
Glamorganshire	.. 2	400	Monmouthshire	.. 2	900
Carmarthenshire	.. 1	100	Notts ..	.. 1	200
Cheshire ..	.. 3	1,700	Salop ..	 6	2,100
Denbighshire	.. 2	550	Staffordshire	.. 2	1,000
Derbyshire ..	.. 4	800	Worcestershire	.. 2	700
Gloucestershire	.. 6	2,850	Sussex ..	.. 10	1,400
Herefordshire	.. 3	1,350	Warwickshire	.. 2	700
Hampshire ..	.. 1	200	Yorkshire ..	.. 6	1,400

Some figures given by Scrivenor are of interest as showing the relation between the charcoal and coke furnaces during the transition time.

1783.—Anderson estimates the annual value of iron manufactures in Great Britain at £8,700,000, and that of steel at £3,400,000.

1788.—Seventy-seven blast furnaces in England and Wales, and eight in Scotland, producing 63,300 gross tons of pig-iron. Of the whole number of furnaces twenty-six used charcoal and fifty-nine used coke. The imports of pig-iron by Great Britain in this year amounted to about 15,000 tons, and the imports of bar iron amounted to 51,469 tons. Mr. Swank gives a table showing the growth of the pig-iron industry of Great Britain from 1788 to 1890. He takes this year 1788, because with it "begins the revival of the British iron industry, which followed the general introduction of coke in the blast furnace, and of the puddling furnace and grooved rolls in finishing iron."

1806.—Eleven old charcoal furnaces producing 7,890 tons; 222 coke, producing 250,406 tons.

Use of Coke in Place of Charcoal.

The trade of the Sussex and other Southern ironworks was a fluctuating one, affected by several causes; one of the first to take effect was the fear of the failure of the stock of charcoal from the denudation of the forests. This was very perceptible in the 18th century.

Another important cause of decay was the large importation of foreign iron in the 17th and 18th centuries. On December 11, 1663, Samuel Pepys had a talk with an iron merchant, who told him, "the great evil of discouraging our natural manufacture of England in that commodity by suffering the Swede to bring in three times more than ever they did, and

* "Notes on the Ancient Iron Industry of Scotland," by W. Ivison Macadam, December, 1886.—"Proceedings of the Society of Antiquaries of Scotland," Vol. IX. (New Series), pp. 89–131

our own ironworks be lost, as almost half of them are already."

The change of coke for charcoal in the manufacture of iron finally closed the Southern ironworks, but it is somewhat remarkable that some of the Southern furnaces did not close down until the beginning of the 19th century.

Chronology.

A few dates are here given respecting the history of the old ironworks of Great Britain and Ireland which, to some extent, supplement the previous notes.

British Iron Manufacture.—Strabo refers to the exportation of iron from Britain in his day, and Solinus not only mentions British iron, but describes the agricultural and other implements manufactured therefrom. In a Latin poem entitled "Reliquiæ Eboracenses," it is asserted that Sheffield was the place from which the Brigantes were supplied with the arms they bore against the invading Romans.

Roman.—The Emperor Hadrian visited Britain A.D. 120, and in the following year there was established at Bath a Roman military forge or fabrica for the manufacture of iron arms. This forge was near to the bloomeries in Somerset and the Forest of Dean, from which it was supplied with the necessary iron.

In the 16th century furnaces were built in the Forest of Dean to re-work the heaps of cinder, and Capel Hanbury, of Tintern Ironworks, was one of the projectors in 1565. Mr. Savery affirms that the Roman cinder-heaps of the Forest of Dean furnished half the iron produced for two hundred years after improved methods came into use. This iron was said to be some of the finest produced.

Altars erected to Jupiter Dolichenus, the protector of Roman ironworks, have been discovered in various places in England in association with the remains of prehistoric ironworks.

Saxon.—Little information has come down to us respecting the iron industry among the Anglo Saxons, although Bede speaks of its importance in the beginning of the 8th century. We know that St. Dunstan was a skilled blacksmith, and that much artistic ironwork was produced about his time.

Norman.—There are several references to ironworks in different parts of the country to be found in Domesday Book, but Sussex iron is not mentioned. As already stated, the earliest record of iron in the county is under the year 1266. In 1160 ironworks had been established by the monks of Kirkstead, Lincolnshire, at Kimberworth, Yorkshire.

In 1279 (7 Edw. I.) iron was smelted in St. Leonard's Forest (which gave its name to the western extension of Hastings), and the works were afterwards carried on by the Crown. In 44 Eliz. (1602) the Forest was leased by the Crown to Sir John Caryll, and in the lease the various forges and the implements belonging to them are enumerated. They were afterwards employed for military stores for the use of Government and so remained until 1643, when Chichester and Arundel were taken by Sir William Waller. Dallaway states that a part of that General's army "was dispatched for the purpose of destroying these and other ironworks belonging to the Crown or to Royalists, which have never since been restored."

1543.—English iron was cast by Ralph Page and Peter Baude in Sussex (Rymer's "Fœdera").

1609.—John Hawes held the site of the Abbey of Robertsbridge, with the buildings, etc., "lying between two fresh-water rivers, abutting at the great stone bridge at the Forge Pond," and "including various buildings for the steel-makers, among which were eight steel forges; also one great gate-house, called the East Gate, employed as a store-house for iron, with a house attached to it for James Lamye, the hammer-man." Steel was also manufactured in several other places, particularly at Warbleton, where is a place still called the Steelforge land, and at Robertsbridge.* In 1623 Robert Sidney, Earl of Leicester, assigned a lease of Udiham iron house, in the manor of Robertsbridge, to John Colpeper and Henry English, with power to dig for iron in any of Lord Leicester's lands in Salehurst, Ewhurst, Watlinge and Watlington. In 1707, Elizabeth, Countess Dowager of Leicester, and John Sidney, her son, Earl of Leicester, leased the Robertsbridge Furnace for eleven years to Thomas Snepp, Sen. and Junr.†

1636.—Proclamation respecting the better management of the iron trade.

1637.—Order in Council to put the regulations in force.

1639.—Both the above instruments were revoked by proclamation given at York (Rymer's "Fœdera," XX. 340).

1750.—Act of Parliament prohibiting the American Colonies from manufacturing beyond the stage of pig-iron.

1756.—Importation of bar iron from the Colonies.

Aluminium Bronze.

According to the "Eisen Zeitung," a 10 per cent. aluminium-bronze alloy which is well adapted for the production of acid-resisting castings, possesses the drawbacks that during pouring considerable scum forms and subsequently shrinkage occurs. As a result, porous places and flaws are caused in the outer skin, as well as in the interior, of the castings. In order to overcome these disadvantages, it is recommended that both the melting and the pouring of the metal should be carried out with great care. Perfect results can only be secured by the employment of clean and pure constituents of the alloy. Electrolytic rather than scrap copper should, therefore, in the first place be used, while 99 per cent. pure aluminium should be selected. The copper should be melted in a graphite crucible covered only with charcoal. When reduced to a molten condition, the aluminium may be added after first being heated. As soon as the latter has melted over the copper, it can be thoroughly mixed by the aid of a graphite rod, the alloying process being effected as the temperature is raised to a point to give a white heat, the alloy being afterwards cast into bars. When required for casting work, great care must be taken in remelting the bars in order that they may not be overheated, and, to prevent any slag in the moulds the metal should be poured at as low a temperature as possible. Furthermore, the alloy should be poured immediately it leaves the melting furnace, as if left it absorbs various gases which may give rise to blowholes in the castings; the metal should, however, be slowly and steadily poured. Green-sand moulds are described as being the best for this work.

Scum formation and subsequent shrinkage can, to some extent, be obviated by the addition of a small quantity of iron, and by de-oxidation by means of magnesium-aluminium. The addition, to the extent of 1 to 2 per cent., can be made in the form of ferro-aluminium, just after the melting of the copper, while the de-oxidation is affected by the use of 50 per cent. magnesium-aluminium, added at the end of the melting operations, a further five minutes in the furnace being allowed. The crucible should then be removed from the furnace, the slag skimmed off, and the metal poured. For a 22-lb. charge, about 0.88 oz. of magnesium-aluminium should be added.

* Lower, "Sussex Archæological Collections," 1849 Vol. II. p. 197.
† Thorpe's "Battle Abbey Deeds," pp. 201, 202.

Properties of Cast Iron.

By Sidney G. Smith.

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Commercial cast iron is composed of those elements which are quoted in its analysis, but as it is an alloy it is recognised that compounds are formed by those elements at definite temperatures. Carbides exist in three different forms, (1) in solid solution, known as Martensite, (2) in segregated patches as cementite, and (3) in fine striations as pearlite; and in the presence of manganese double carbides are formed. Graphitic carbon in several forms, also the silicide of iron, Fe_2Si, phosphide of iron Fe_3P, and sulphide of iron FeS, exist and exert an influence upon the physical properties according to their content and condition. But the physical properties of an iron of a certain analysis can be quite altered by rapid or chill cooling, and even in normal cooling an iron of identically the same analysis and subjected to the same treatment will sometimes give different results. In this connection may be cited some of the research work conducted by Messrs. Cook and Hailstone. The tests lasted over a period of 60 consecutive days, and are classed as A and B series.

Table I.

	Tensile test in tons per square inch.		Transverse test in cwts. on 1 in. square bar 12 in. centres.		Transverse test in lbs. on ½ in. square bar 12 in. centres.	
Series.	A.	B.	A.	B.	A.	B.
Highest ..	12.9	18.3	28.5	32.25	550	575
Lowest ..	8.7	13.1	19.0	25.0	390	375
Average ..	10.7	15.8	23.1	29.1	465	450
Number of tests taken ..	60	60	33	30	58	59

It will be noted in both series that the averages of transverse tests of both A and B series, although different, ran close to each other, especially with the ½ in. square bar. For the first investigation a low bar of the A series and the highest bar of B series were examined. The chemical analyses of the two bars were as follows, with the tensile results:—

Table II

Test series.	A.	B.
Tensile test result.	9.1 tons per square inch.	18.3 tons per square inch.
	Per cent	Per cent
Total carbon	3.250	3.192
Graphitic carbon	2.397	2.289
Combined carbon	0.853	0.903
Silicon	1.328	1.314
Sulphur	0.095	0.101
Phosphorus	0.923	0.909
Manganese	0.290	0.335

It will be seen that the analyses were practically identical.

Another example of the effects of rate of cooling may be given. In this case four bars were cast in one box from the same ladle of metal (ordinary No. 3 pig-iron). This experiment showed to a striking degree the effect of different rates of cooling, which were regulated by means of cast-iron chills of different thicknesses placed in the mould for three of the bars, the fourth being unchilled. The result of tests and the analyses of the iron were as follows:—

Table III.

Tensile strength.	Unchilled bar.	Chilled bar.
	8.1 tons per square inch.	15.2 tons per square inch.
	Per cent.	Per cent.
Total carbon	3.284	3.280
Graphitic carbon	3.190	3.190
Combined carbon	0.094	0.090
Silicon	3.366	3.368
Sulphur	0.025	0.026
Phosphorus	1.522	1.524
Manganese	0.231	0.230

Mr. E. A. Custer, during his experience in making castings with permanent iron moulds, observed that the iron so cast was cleaner, stronger and quite free from blow holes or gas holes, and gave better test results than castings made in sand. With this method the castings are stripped as soon as they are set, and then allowed to cool off normally. He has also demonstrated that cast iron if quenched at a temperature near the freezing point, will take a temper and retemper, and will be as serviceable and durable as some kinds of tool steel, and, what is most surprising, this can be done in a wide range of compositions of ordinary cast iron. The following are two analyses of iron so treated:—

Table IV.

	Per cent.	Per cent.
Total carbon	2.65	3.02
Combined carbon	0.44	1.54
Silicon	2.28	2.24
Phosphorus	1.21	1.12
Sulphur	0.108	1.01
Manganese	0.41	0.38

Mr. Custer contends that "If molten iron be instantly cooled to 1,000 deg. Fahr., all the carbon will be in the combined form. If it be instantly cooled to the point at which iron sets and then be allowed to cool normally, the carbon will be in the combined form at the time of setting, but will change to the free form as the cooling progresses. The following analyses give a good idea of this action, the pieces in question being 6 by 1¼ by ½ in.

Table V.

	Combined carbon.	Graphitic carbon.
	Per cent.	Per cent
Cast in sand and cooled normally ..	0.27	3.20
Taken from permanent mould at bright yellow and quenched	1.50	2.02
Taken from permanent mould at bright red and quenched	0.49	3.1

"It will be seen that two-thirds of the combined carbon has been changed in the few seconds required

to cool from bright yellow to light red. The free carbon in all these castings is not in the form of graphitic carbon as usually seen in ordinary cast iron, but partakes more of the character of annealing carbon. It is probably this characteristic of the carbon which gives permanent-mould castings their unusual strength and toughness." Of course, the actions involved in the cases cited have their limitations, owing to thickness of metal affecting rapid cooling. It should be borne in mind that the altered condition of the carbon does not give hardness, closeness and density at the expense of ductility and resistance to pressure.

Reverting to the question of normal cooling with castings made in sand, the foundry chemist (the employment of whom is increasing where the foundry is sufficiently large to pay for the upkeep of a laboratory), when he has had sufficient foundry experience and acquired some knowledge of the kind of iron best suited for various kinds of work, usually fixes upon a certain analysis for a certain kind of work. The following, in connection with valve castings, may be quoted from conclusions arrived at by Mr. W. D. Rudy :—"That the maximum density of cast iron occurs when the silicon is at 1 per cent. mixtures, whilst the other was made without any knowledge of chemistry."

It has already been shown that the same analysis in different brands of iron will not give similar results. Mr. H. M. Ramp, discussing the production of steam-cylinder castings, emphasises this contention. He says :—"If the cylinders are of average section, 1¼ in. or under, the following analysis will give a close, clean, solid casting :—Silicon, 1.60 to 1.80 per cent.; sulphur, under 0.10 per cent.; phosphorus, 0.90 to 1.00 per cent.; manganese, 0.50 to 0.80 per cent. If they run heavier, the silicon can be reduced as low as 1 per cent. and the manganese increased to 1 per cent. according to section. To make this mixture so that it will possess the required qualities, a great deal more than the mere fact of conforming to the chemical analysis must be observed. The character of the pig-iron must be known; its physical qualities or working qualities are of as much value to the foundry as all the chemical determinations possible, for there are physical characteristics in pig-iron—we will call them physical because chemistry has not yet revealed them—that cause two irons from different furnaces, but practically of the same analysis, to act and work quite differently."

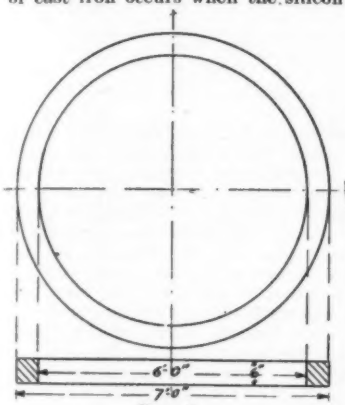


FIG. 1.

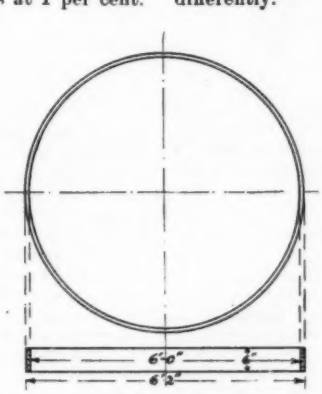


FIG. 2.

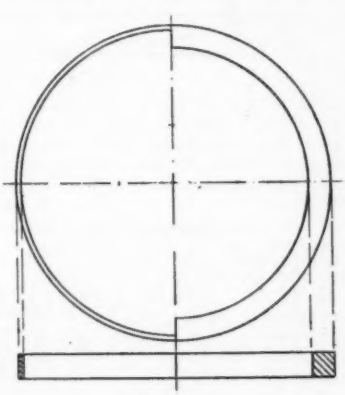


FIG. 3.

That the strongest iron at 1 per cent. silicon contains just a trifle over 1 per cent. manganese, its strength lessening with corresponding decreases in the amount of manganese. That the increase in the percentage of manganese up to 1 per cent. tends to produce a fine, close grain, tough but easily machined. That with 1 per cent. each of silicon and manganese the strongest cast iron contains about 0.10 per cent. sulphur. That the lower the phosphorus, consistent with the necessary fluidity, the greater is the strength." According to this, the analysis of the strongest and toughest iron is :—Silicon, 1 per cent.; manganese, 0.90 per cent.; phosphorus, 0.50 per cent.; sulphur, 0.10 per cent. Now foundry chemists, though it may be urged that they work upon scientific lines, may be either good or otherwise at their work, and it is possible for the term "science" to be abused. For instance, the following came under the notice of Mr. E. Adamson, and was quoted by him in a Paper given before the Staffordshire Iron and Steel Institute (1909) :—"I saw a large engine where a cylinder lining had been worn out in three weeks, and another which had only been in a fortnight was about done, whilst the previous one had been in nearly three years. All these linings were made by the engine builders, but the two new ones were made on scientific chemical

Mr. J. F. P. Lewis, in a Paper on "Improved Cast Iron,"* says :—". . . founders chose silicon as a sole basis for adjusting their mixtures and regarded it as *the* governing element; and this consideration of silicon has persisted almost universally in foundries, and, in the opinion of the author, has brought the trade of ironfounding in its connection with high-grade mechanical construction almost to the verge of ruin. Silicon is certainly one of the governing elements in cast iron, but by no means the only one. . . . . it will be granted that the arrangement of iron mixtures on a silicon basis is absolutely unscientific, and that within reasonable limits. . . . . the final specific density of the casting will be the index of its mechanical and physical qualities rather than its chemical analysis."

The writer does not wish to underrate the value of the chemist in the foundry, and has previously made his position clear regarding that matter; but he would state that while for ordinary castings that are not required to stand any particular tests, he can give an approximate analysis that will give satisfactory results, such results will depend largely upon the manipulation of the iron, and the method of moulding, which is an important matter often

* FOUNDRY TRADE JOURNAL, February, 1911.

overlooked and almost unknown to the inexperienced chemist. It may, then, be reasonably asked that if analysis cannot be relied upon, and fracture is deceptive, and grade numbers are of little importance, what is the position of the foundry regarding definite knowledge? The reply is, that until more light can be thrown upon the complete nature of cast iron, success in the production of sound and satisfactory castings will chiefly depend upon those under whose charge the castings are produced, and the essentials are keen observation, best method of moulding, correct design, and adaptability resulting from years of experience, continual watching and comparison of results. When the chemist is foundry-trained, the foundry foreman, if he is abreast of the times, will have a true helpmate. Also, engineers should acquire the knowledge of good and practical design and insist upon such designs.

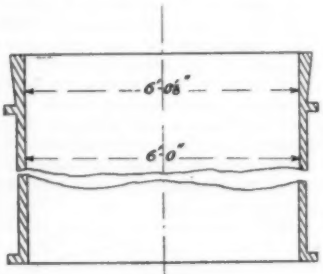


FIG. 4.

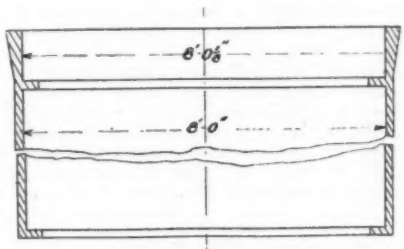


FIG. 5.

Unequal and Varied Contraction.

The usual contraction allowed in white iron is ¼ in. to the foot; in grey iron from ⅛ in. to a $\frac{1}{10}$ in. per ft.; but quite apart from the accepted constant contraction there will be a variation relative to thickness of the section, quality or composition of the iron, and to some extent the rate of cooling.

For instance, if two rings are made with the same grade and brand of iron, one being 6 ft. inside diameter by 1 in. thick by 6 in. deep, the other being the same diameter and depth, by 6 in. thick (see Figs. 1 and 2), it will be found by measurement that the ring 1 in. thick will contract more than the ring 6 in. thick. This one example is quite sufficient to show its importance where accurate sizes in large thick and thin castings are desired. The same law applies to any design of casting regarding thickness. What the actual difference would be it is difficult to say. To take one exceptional case, if one-half of a 6 ft. diameter ring was 6 in. thick, the other half 1 in. thick (see Fig. 3) before the casting cooled it would probably fracture.

As different qualities of iron vary in contraction, the writer has many times found with large diameter castings, such as external and internal flange cylinders where a large thick feeding head has been carried round above the top flange, that the diameter at that end of the casting has been large, due to the thick section of iron not contracting uniformly with the thin section of the casting proper (see Figs. 4 and 5). Rapid cooling after a casting is solidified precipitates contraction, and probably increases it; if the casting so treated is uniform in section and the cooling is not too rapid and is distributed all over the casting, no harm may be done, but otherwise it is a very unsafe proceeding. To endeavour to prevent a casting contracting by means of stays is foolish, because if the attempt was successful there would probably exist a rupture somewhere.

Figs. 6, 7, and 8 refer to almost any kind of half-round casting of large diameter, such as clips, clip collars, box parts, etc., which are half-round when moulded, but in which, when the castings are cold and taken out of the sand, the diameter, apart from the usual contraction allowed, is less than the pattern, although the half-diameter in depth may be about the correct size. The width has contracted proportionately more than the depth—that is, the casting is not a half-circle, and when a pair of such castings are put together to form a circle they are oval instead. The extent to which they are oval will sometimes depend upon the size of the casting, cooling, thickness, etc. The sizes given on the sketches are only approximate. These castings, for convenience and economy, are usually moulded and cast in the position shown in the sketches, but if the reverse method be adopted, *i.e.*, moulding and casting the opposite way up, the variation in contraction will not be so marked. To make perfect half-round castings, however, in the way shown in the sketches, the pattern must be diametrically out of the round to produce a proper circular casting, and this can either be accomplished with the ramming board or by a pattern made or built sufficiently out of the circular, as ascertained by results in practice. It is unwise, if it can possibly be avoided, with large castings of irregular design and thickness, to interfere with normal cooling or contraction except to assist it. Such assistance should be given, and provision made for contraction to take place with the normal cooling of the iron. The writer has adopted various means to divert contraction in certain directions, but even where that may be done the

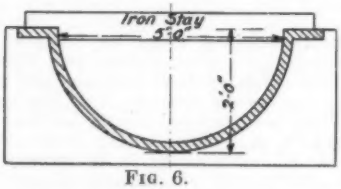


FIG. 6.

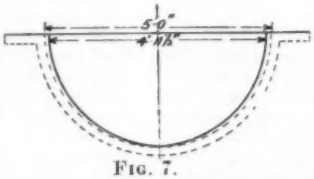


FIG. 7.

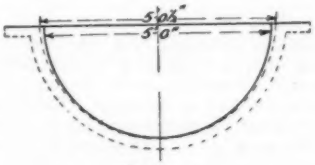


FIG. 8.

casting must suffer, because of the distortion of the natural formation of molecular or crystaline structure.

Molecular Attraction.

A difficulty in the foundry often arises in trying to keep long thin castings straight and in shape. This difficulty is experienced with long bedplates, chequer plates, flat piles, segments, plain plates, the length of which may vary from 10 to 30 ft. and the thickness from $\frac{3}{4}$ in. to 2 in. Many of these castings in cooling will assume (according to design) a shape not quite in line either longitudinally or radially with the pattern. This phenomenon is often

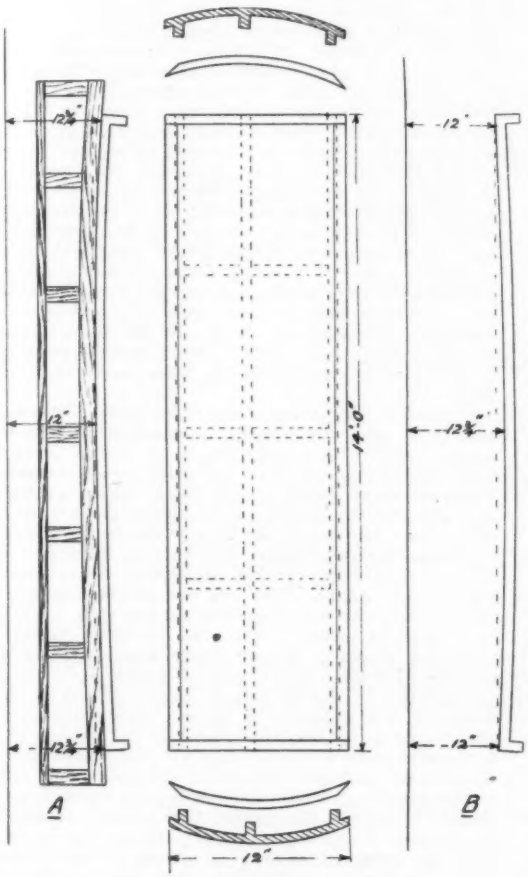


FIG. 9.

very difficult to control. Various means are adopted to keep the castings in their proper shape when cooling, such as weighting, cramping, making bare or covering the casting in certain places, the idea being to influence the tendency of deformation, which is sometimes counteracted and at other times not. Such means are justified under certain circumstances, but the effect upon the casting is more or less detrimental, as undue stresses and liability to fracture are incurred, which would not exist in normal cooling. When a number of castings are required the pattern should have sufficient camber or be so built out of shape that cooling deformation will result in the correct shape. This can be ascertained approximately after the first few castings have been made and measurements checked when the allowance has been made. The same conditions in regard to quality of iron, stripping, etc., must be followed with the remainder as with the first two, if not, probably other variations will appear.

Fig. 9 is a sketch of a pattern 14 ft. long by 12 in. wide, varying in thickness from $\frac{3}{4}$ in. to a feather edge at the sides. Longitudinally the castings are required perfectly straight, and to obtain that $1\frac{1}{2}$ in. of camber is allowed, the rounded pattern producing a straight casting. In this particular case a ramming turnover board is used. The camber is built in the turnover board and the pattern built to follow it. Practice has shown that if the pattern

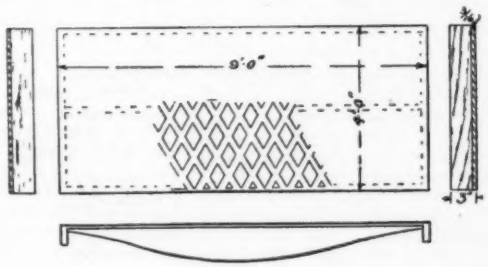


FIG. 10.

is made straight the casting would be round, as in sketch.

Fig. 10 shows a diamond chequer plate 9 ft. long by 4 ft. wide by $\frac{3}{4}$ in. thick, with flanges and middle rib running lengthwise; $\frac{3}{8}$ in. was allowed in the turnover board by means of two narrow wood strips $\frac{7}{8}$ in. thick across each end of the board, and the pattern following gave the desired camber and made a straight plate. Of course, winding strips are used when levelling the board, and so with long thin-section patterns it is preferable to get the required camber in the pattern rather than manipulate the casting when cooling. It may be stated here that during the interval that iron is cooling from the molten to the solid state, various actions, segregations, and separations are taking place, such as expansions, arrests, formation of graphite and eutectics, and the drawing or sinking away from the thicker sections of the thin sections, leaving (unless otherwise prevented), spongy, porous places. After the period of solidification is passed the formation of

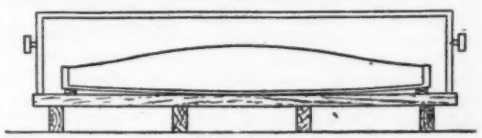


FIG. 11.

graphite is continued, and contraction proper begins. What that means, or the measurement of its compressing power will probably never be known; it can only be imagined what a crushing, packing and tightening together of the crystal structure must occur.

Slow cooling favours the formation of graphitic carbon and rapid cooling favours the retention of combined carbon; consequently the percentage of the two carbons in a casting depends chiefly upon the rate of cooling and the original composition of the iron when charged in the cupola, or rather when it leaves the cupola. It may also be stated, in regard to the changes that take place in the cupola

during melting and which slightly alter the composition of the iron of the original charge when tapped, that it is important that such changes should be estimated, though they will to some extent depend upon the general working of the cupola, the quality of coke and flux, and the pressure of blast, etc.

The following figures are from experiments in re-melting changes by Messrs. Fairburns :—

Analysis.

Times remelted.	Graphitic carbon.	Combined carbon.	Silicon.	Phosphorus.	Sulphur.	Manganese.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	2.73	0.60	2.48	0.31	0.04	1.09
4	2.54	0.80	1.88	0.30	0.10	0.44
6	2.08	1.28	1.16	0.28	0.20	0.36

It will be noted that each remelt shows a reduction in silicon, graphite, carbon and manganese, and an increase in sulphur and combined carbon. Mr. Guy Johnston proved a reduction of 0.15 to 0.30 per cent. in silicon and an increase of 0.04 in sulphur. The reduction of silicon occurs through some of that element being burnt and some passing into the slag, during melting, caused by oxidation and the action of the flux. The increase of sulphur is due to absorption from the coke, owing to the affinity of sulphur for iron. Both of these changes increase the combined carbon at the expense of the graphitic carbon and silicon, which loss considerably hardens the iron at each re-melt. It is then, obvious that should the remelts be continued the result would be white iron.

Charcoal Pig-Iron.

In the course of a Paper on "Wood Charcoal, its Manufacture and Uses," read recently by Mr. W. W. Ashton Bost, before the Institute of Marine Engineers, the author, referring to the demand (which at one time used to be extensive) for charcoal for use in the manufacture of charcoal iron, drew attention to the issue of an interesting pamphlet by Mr. G. Turner, of Glasgow, on "Ancient Forestry and the Extinct Industries of Argyllshire and part of the Adjacent Counties," from which he culled the following interesting information :—

From the twelfth century onwards, Scotland, on account of its woods, produced charcoal iron. In many cases bog iron was used, but traces have been found where shallow pits were mined to get the hematite. It was found cheaper to carry ore to the charcoal than charcoal to the ores. Each furnace devoured the wood annually from 120 acres of land, so that the furnaces were constantly being shifted to follow the wood. As a consequence there have been found in the West of Scotland no fewer than 2,000 slag heaps, but many of these bear evidence that once the timber had grown up again in the locality, the furnaces came back, and the slag heap was again utilised. At first the furnaces were built in valleys open to the prevailing wind, thus getting a natural blast, but when bellows were discovered many went to water courses where they could utilise the water power while also being near the wood. The small furnace originally used produced small blooms, which were slightly spongy but malleable Later on, as furnaces got bigger, the iron became more of the nature of cast iron, till now it is entirely in that form.

The author went on to refer to the lecture by Mr. Henry B. Wheatley, given before the Royal Society of Arts, which appears in the current and last issues of the Foundry Trade Journal, under the title of "The Early History of Ironfounding." This author, he said, gave some very interesting information re charcoal ironworks in England, but overlooked those of Messrs. Harrison Ainslie as being still in existence. It was in Scotland that Messrs. Harrison Ainslie started their Lorn Works at Bonawe in Lorn (Argyllshire) in 1753, removing them later to the Lindal Moor Mines near Ulverston, and he (the author) was indebted to them for the following information :—

"We are still manufacturing charcoal pig-iron, our brand being known as 'Lorn,' and we consume upwards of 3,000 to 4,000 tons of lump charcoal per annum, which we require in the manufacture of this special iron. The furnace owned by this Company and situated at Backbarrow, on the River Leven, is the only charcoal furnace working in Great Britain. This furnace was erected in the early part of the eighteenth century, and with the exception of heightening the original furnace to increase its capacity the process of manufacture is identical with that used at that time. The furnace produces about eight tons per day of cold-blast 'Lorn' charcoal pig-iron. This iron is expensive to manufacture, and is the dearest on the market, but in spite of the cost of manufacture it has a ready sale, and goes to Australia, New Zealand, Japan, China, Europe, and is very largely used in the United States, where it is mixed with other irons to make malleable castings.

"Charcoal iron is made very extensively in Sweden and in Russia; the Swedish particularly is sold in Great Britain, and competes to a certain extent with the 'Lorn' charcoal pig-iron. . . . For many years the manufacture of the 'Lorn' brand of charcoal pig-iron was intermittent, and a great deal of the market was lost at the time owing to the irregular manufacture of same, the various users of our 'Lorn' iron being unable to depend on receiving their requirements. This was due to short supplies of charcoal. At that time the furnace was entirely dependent on charcoal produced in Great Britain, the chief source of supply being what was termed country charcoal, viz.: charcoal burnt in kilns in the coppices in the immediate neighbourhood of the furnace. For a radius of 30 and more miles from the furnace it was the practice of landowners to grow coppice wood specially for the manufacture of charcoal, for which there was always a ready sale to the Backbarrow furnace, and coppice wood is still grown throughout the English lake district, in which the furnace is situated, for this purpose; but as time went on fewer coppices were grown, so that there came a time when the local supplies were insufficient for the requirements of the furnace, and to augment it chemical charcoal was bought, and all surplus chemical charcoal on the British market was sold to the Backbarrow furnace. Even this was not sufficient to keep the furnace going for more than four to six months per year. There being an increasing demand for the 'Lorn' brand of iron, other sources of charcoal had to be found, and we are now importing charcoal very largely from the Continent, it being found that the best chemical charcoal could be delivered at our furnace from abroad at prices equal to and even less than those which the chemical-charcoal manufacturers in this country insisted they required to make their business pay."

Economy through System.

By James Kay.

In repetition work first cost as regards pattern and moulding boxes is of secondary importance to the ultimate cost of producing the casting, and the founder is therefore not worried with the instructions, "As little time on the pattern as possible; only one off." But in the writer's foundry that injunction is ever present. We seem to make everything under the sun; rope pulleys of various diameters and every conceivable shape of groove; strap pulleys of various strengths, from a loose pulley to a main driving pulley; spur and bevel wheels, helical and worm gears, etc., etc. These are generally made singly, and as a rule in one day, and also as a rule in the one day the order comes in. In this class of work the castings turned out have to be quite respectable, and the cudgelling necessary to fulfil these conditions is at times very considerable, especially when it has to be cast, "next blow, certain."

In order to facilitate quick delivery, to economise pattern-making and to produce respectable castings, the writer set about a process of organisation. The first problem tackled was that of rope pulleys. As a rule we form the grooves by cores made from a

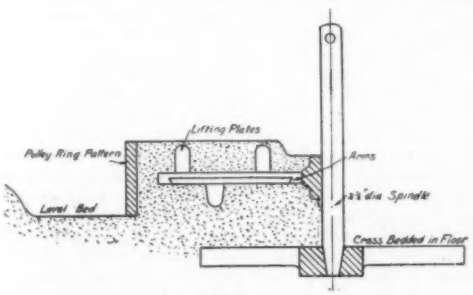


Fig. 1.

segmental box, these boxes numbering hundreds. Some kind of record was kept, pages being alloted to the various diameters of ropes. The diameter of pulleys made claiming a particular diameter of rope, say 1¼ in. rope, were entered :—

Diameter.	1¼ inch diameter rope.		
Inches.			
30	2 grooves	3 grooves	5 grooves.
48	1 groove	4 grooves	
54	6 grooves	8 grooves	
27	2 grooves	4 grooves	
22	1 groove	5 grooves	

The number of grooves of each pulley were entered as the box happened to be altered for a particular order. This was quite all right in a way, but the elusiveness of the grooves which happened not to be in use was marvellous. The system might be fairly satisfactory where the boxes were few. But in place a system which was quite simple was evolved for keeping these boxes in order, and at hand in a moment. We changed to the new system as the boxes were used. But before detailing the system, our usual mode of moulding rope pulleys or rope wheels might be mentioned.

For reasonable diameters, say from 18 in. p.c.d. to 72 in. p.c.d., we use a pulley-ring pattern and board, the arms being lifted with plates, as Fig. 1. A level bed is swept from the spindle, this bed being made bigger in diameter than the outside of the groove cores, the bed being the depth of the pulley below the floor level. The pulley is placed on this bed, centred from the spindle, the arms rammed up at the required depth, plates bedded in and the joint

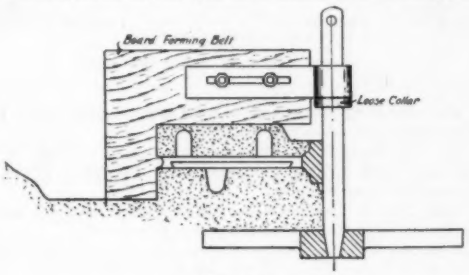


Fig. 2.

made and rammed up to the required depth of rope pulley.

If the pulley-ring pattern happens to be on the big side, this surplus sand is strickled off and belt if required, formed by board, as Fig. 2. The plates are lifted, the arms finished and put back, and the mould finished.

The groove cores are then set with thickness pieces, and the back of them is then rammed with black sand, a flat top part rammed up and the centre core set, then the boss covered with a plate (see Fig. 3). For narrower pulleys boards are used. In nearly every case a board is associated with the rope pulley being made. This procedure, however, does not apply to bigger pulleys and special pulleys, which fairly frequently have to be put through the foundry.

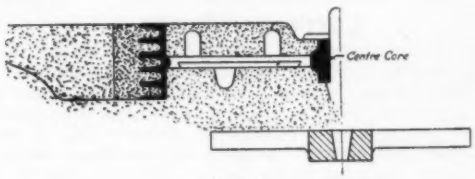


Fig. 3.

Reference may now be made to the system for keeping these boxes in good order. As many pages as considered necessary for each diameter of rope were allotted, and each page was drawn up as follows :—

Dia. at C. of rope.	No. of grooves.	S.O. made for	Board No.	Core-box No.	Centre of ropes.	Remarks.
Inches.						
36	3	2,962	E 40	E 40	Standard	
36	5	2,476	E 48	E 40	,,	
36	4	2,482	E 56	E 40	,,	
48	5	2,498	E 57	E 57	,,	
48	3	2,498	E 58	E 57	,,	
48	2	2,498	E 59	E 57	,,	

The number of last box or board used was noted, and a new board or box made after was stamped the next number. Each core box made was constructed as if for use for a five-groove rope pulley. This economised time when altering from two or three to four grooves, and so on.

Another book was set aside for rope-pulley orders only. For each pulley ordered the foreman pattern-maker entered up in this book all particulars necessary for a man to get it ready for moulding. For example:—S. order 2482; 1 rope pulley 36 in. diameter, 4 grooves by 1¼ in. ropes; bored, 4 in. diameter and keywayed.

The five-groove core box is altered to four grooves, and a new board will be required, so it is entered up as follows:—

S.O. 2482	1 rope pulley 36 in. × 4 grooves × 1¼ in. rope, bored 4 in. Boss 8 in. diameter × 5½ thr. 6 curved arms type B. Corebox No. E 40. Board No. E 56.

All splitting snugs, etc., that have to be made for this order are stamped E 56.

If they happen to be used for another order, they are recorded as having been used for that particular order number.

The boards, core-boxes, bosses, etc., are all kept in their respective places in strict rotation.

This system may appear unnecessarily complicated, but the writer has found that the keeping of the records saves considerable time, not only by being able to put one's hand on what is wanted, but also in getting the work through the shop. The foreman pattern-maker need simply to hand the rope-pulley order book to a man, show him which pulley is required, and he is able to go right through with it till the job is ready for checking. Although the writer has dealt with only one question, everything in the pattern-shop of a jobbing foundry can be systematised in such a manner as will economise time in getting the order to the moulder's hands. By a judicious system, hands can be laid on any pattern at a moment's notice. All work after a time is necessarily more economically produced, if a record is kept of just what is required for certain orders. There is no gnashing of teeth over whether a certain arm pattern was used for a particular job which has to be repeated after several months.

Correspondence.

To the Editor of THE FOUNDRY TRADES JOURNAL.

SIR,—With reference to Mr. Cook's letter on page 170 of your last issue, it is perhaps unfortunate that you printed a condensed report of Mr. Cook's Paper. The inference is apparently combined carbon, which is referred to on the top part of page 44 of your January issue.

"Saturation point of carbon"—as usually understood—appears to be a dangerous term to use. Authorities such as Abel, Arnold, etc., claim C. 0.90 per cent. as the "saturation point"; on the other hand, others say it is about C. 4.25 per cent.; and later researches have shown that the "saturation point" is very much higher than even the latter percentage. All appear to be correct from the different points of view, and if Mr. Cook does not refer to any of these "saturation points" of carbon, he is introducing something entirely new, of which your report of his Paper gives no indication.

Yours, etc.,

E. ADAMSON.

18, York Street, Sheffield,
March 13, 1914.

Making Fly Groove Pulleys in Segments.

Various methods of moulding segment pulleys are in practice to-day. The following illustrates one method which has given good results. Fig. 1 shows a part plan of a 30-ft. grooved pulley with 10 arms and 16 grooves. The arms may be made as at *a* or *b*, Fig. 1; both can be formed by cores as shown in Fig. 3. Only one-half of a pattern is required; this is rammed up in a core box, grids being used to strengthen the cores, and for convenience of lifting and setting they are best jointed at the line *a*—*a*, Fig. 3. The bottom cores are set on a hard level bed, as in Fig. 3, the cotter core *b* is set, then the top cores are placed on, the core *c* is set to the open end *d* and bolt-hole cores are pushed through the prints *e e* into *f*. The top half is closed in a like manner, *g* in the bottom core being the runner, which is carried to the top by a peg on the outside. Floor sand is rammed all round the mould, which is then weighted ready for casting. When the arms are round, as *b*, Fig. 1, a print is formed in the core *c*, Fig. 3, and a barrel core runs right through the arm.

The boss is the heaviest single casting for such pulleys (see plan, Fig. 1, and sections, Fig. 2). Two plates are required for this, as in Fig. 4, top and bottom plates. These are placed over a spindle and swept up in loam with a board. When dried and blacked the bottom plate is set in a pit, and the cores, Fig. 5, are set to form the outside. A curb or box-part should be placed round the outside, allowing about 18 in. clearance (see Fig. 4). The cores, Fig. 5, are then wedged with bricks to the curb, each opening in the centre of the cores being left clear (*d*, Fig. 4). The curb prevents the mould from straining when cast. Half of the centre core (Fig. 6) is then set (*e*, Fig. 4). The next core is Fig. 7, and this should be kept towards the centre till the print end *a* enters the opening in Fig. 5; it is then set in position and requires studs top and bottom. The tenth core requires a loose piece, as shown in Fig. 5, so that it can drop straight down, because there is not sufficient space to take it towards the centre. The openings at the back of the cores can now be rammed up, provisions being made for taking the vents off the top half of the centre core. The cotter cores *g*, Figs. 4 and 7, are set, and the top loam plate lowered on and bolted to the bottom plate, when the mould is made ready to cast.

Fig. 8 is the pattern for the rim segments, and Figs. 9 and 10 the boxes they are mounded in; *a*, Fig. 10, is a loose piece bolted to either side of the box. A hard bed is made and strickled off to *b*, Fig. 10; the pattern is set on this bed and rammed up to the joint *c*, Fig. 10; the cope, which has bars (Figs. 11, 12, 13) to match the pattern, is placed on, runner and riser pegs are set to correspond with *a a*, *a*, Fig. 8, and the cope is rammed up. The boxes, *b*, *b*, Fig. 8, are loose, also the print *c* for the barring teeth and the rib *d*. All these lift with the cope and are withdrawn when it is turned over. The cores *e*, *e*, Figs. 8 and 14, are set in the cope and fastened by hook bolts *f*, Fig. 14. The barring teeth cores are set in sections and fastened with spikes. If the casting is very heavy, the cope is best made of dry sand. The pattern is now drawn from the bottom part and groove cores (*d*, Fig. 14) set on the bottom bed. Fig. 15 is the runner core; it has a gate into each groove and sets one end of Fig. 8, the other being a plank core. The mould is then ready for closing.

It will be noticed that the moulds are nearly all formed with cores and if well set out can be handled quickly; neither is there a great amount of tackle to make for the job. The rim segment boxes can be used for a few patterns within a certain radius, only the plate (*a*, Fig. 10) requires to be altered to the same radius as the pattern.

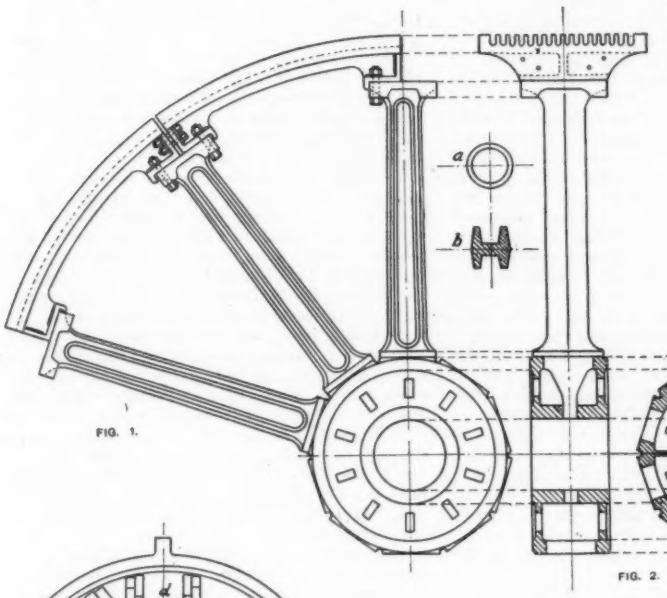


FIG. 1.

FIG. 2.

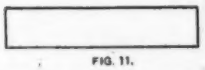


FIG. 11.

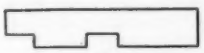


FIG. 12.

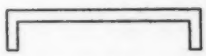


FIG. 13.

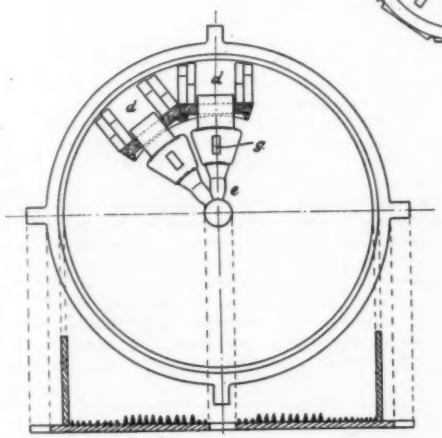


FIG. 4.

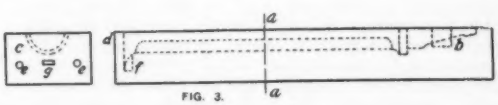


FIG. 3.

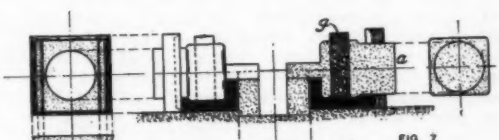


FIG. 7.

FIG. 5.

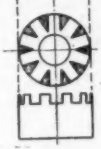
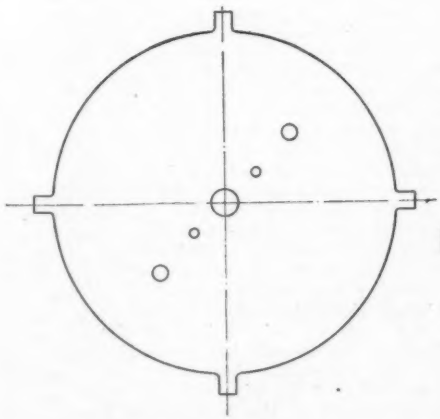


FIG. 6.



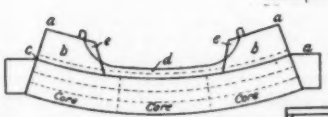


FIG. 8.

FIG. 15.

FIG. 9.

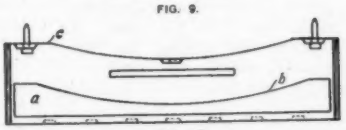


FIG. 10

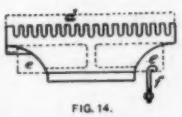


FIG. 14.

Effect of Oxygen in Cast Iron.*

By J. E. Johnson, Jun.

The old school of metallurgists, who knew but little chemistry, always insisted that there were fundamental differences in quality of pig-iron which were not revealed by analysis. The more ardent advocates of the newer theory of chemical control ridiculed this view. Those whose position forced them to look for the facts, from whatever source derived, came gradually to believe that while the theory of chemical control was in a broad way correct, there were certain facts which this theory did not cover, and that the old-school metallurgists were undoubtedly right as to this.

In our search for the explanation for these discrepancies, there seemed, after the most careful consideration, to be two facts which might be taken as established :—(1) That certain irons possessed a quality as they came from the furnace which was preserved on remelting, and which reappeared in castings of which these irons formed an important ingredient. (2) That the rarer elements, such as nickel, cobalt, chromium, titanium, vanadium, and the like, while not absent from the point of view of ultimate analysis, were in such small quantity and varied in ways so entirely independent of the quality of the iron that the explanation could not be attributed to them.

In spite of the certainty in our own minds regarding conclusion (1), and the amount of qualitative confirmatory evidence we had on the subject from innumerable users, we felt that there might be some hesitation on the part of others in accepting it, and we accordingly decided to make a series of tests which should, if possible, be so conclusive as to admit of no dispute. We took six irons constituting three pairs, the irons of each pair containing the same silicon (approximately), but having a different fracture and different strength, as shown by test bars cast from the furnace. The silicon of the three pairs was about 1.90, 1.0, and 0.70 per cent. We remelted these in twin crucibles and cast test bars from the re-melts. In addition to the silicon we determined the graphitic and combined as well as the total carbon in each iron, both before and after remelting. We also made photomicrographs of the original pig and of a test bar from the re-melt, both etched and unetched, for each of the six irons.

To show quantitatively the relation between strength, combined carbon, and graphite, we made combined carbon determinations, by difference in all cases, on the 1-in. bars, but the greater chilling of 1-in. bars in the medium No. 3 iron threw the combined carbon far beyond the eutectoid ratio, and we did not think this constituted a fair comparison. We therefore determined the combined carbon in all the 2-in. bars, taking the sample from the exact centre of the broken face of the 2-in. bar, so as to make the results as nearly comparable as possible in each case. These results are shown in Table I. In pair 1, silicon 1.90 per cent., the combined carbon in the strong iron was 0.65 per cent., and in the weak iron 0.78 per cent. The graphite in the strong iron was 3.40 per cent., in the weak iron 3.30 per cent. In pair 2, 1.0 per cent. silicon, the strong bar contained 0.96 per cent. combined carbon, the weak iron 1.13 per cent. The graphite was exactly the same in both, 3 per cent. In pair 3, 0.70 per cent. silicon, the combined carbon in the strong iron was 1.20 per cent., in the weak iron 1.29 per cent. The graphite in the strong iron was 2.90 per cent., that in the weak iron 3.20 per cent.

In every one of these cases it will be seen that if we take account only of the quantity of combined carbon as increasing the strength of the matrix and that of graphite as reducing the same, we shall get results exactly opposite to the actual ones, except as regards the graphite in pair 3, and even here the difference in favour of the strong iron is slight. It may be that the matrix is somewhat stronger in the strong iron, but one is forced to the conclusion that the principal reason for the difference is the shape and size of the graphite formed in the two cases, and that quantitatively this difference is ample to account for the difference in strength.

It seemed inconceivable that a quality which would survive remelting and superheating to a point well above the fusion point, as in foundry practice, should be a purely physical quality. In other words, if one iron were better than another because cast at a lower temperature, for instance, and for no other reason (both being identical in analysis); when both were remelted to the same temperature and recast under the same conditions, it is incredible that they would not lose the difference in quality due to this difference in original casting temperature. As the difference in quality evidently did persist in spite of remelting, it seemed to me necessary to believe that the difference was a chemical one.

As a consequence of this conclusion, and of the establishment to our satisfaction of the second fact mentioned, that the less common elements were not responsible for these differences in quality in general (though undoubtedly they exert marked influence in special cases), it seemed inevitable that some of the common elements, not ordinarily determined, must be accountable for these variations in quality. Of these, the most universally present in the blast-furnace, oxygen, nitrogen, and hydrogen, are the most common, and seemed a likely field for investigation.

Some metallurgists have taken the view that it was impossible for oxygen to exist in the presence of so highly carbonised a product as cast iron, and at so high a temperature as that of the blast furnace, but about 10 years ago I had made certain observations which seemed to me to indicate strongly the presence of oxygen in cast iron. Marked differences in the fracture of the iron for a given analysis were observable according to whether the iron was "wild" on irregular furnace conditions, or whether the operation was normal and the iron "quiet." On white irons, in good normal working condition of the furnace, the fracture of the chill pig was practically square, with clearly-marked acicular crystals running perpendicularly from the chilled surfaces of the pig, even from the top in some cases, and clearly showing lines running from the centre to the corners, these lines being where the sets of crystals from adjacent sides met. On a "wild" iron of similar analysis the fracture was smooth, but conchoidal rather than square, with a complete absence of crystals radiating from the sides of the pig, and, of course, a corresponding absence of the interference lines of these adjacent sets of crystals running to the corners.

* Abstract of Paper read before the American Institute of Mining Engineers, February 18, 1914.

Irons with higher silicon when made on a smoothly-running furnace had a comparatively slight chill. Such as there was showed strongly-marked acicular crystals similar to those in the white iron, the grain quite open and the colour light. When made on a wild-working furnace, iron with approximately the same silicon had greater chill with absence of crystals, while the grey portion was exceedingly fine-grained, and dark, almost purplish in colour, so as to give it a velvety appearance. In coke practice a wild-working furnace is almost always associated with higher sulphurs, and the irons last described, both white and grey, came to be cordially detested, as showing, even in advance of analysis, high sulphur. It is a matter of much interest to observe that the white irons showed in an increasing degree, as they became wilder, cleavage surfaces which were discoloured with the blue, red, and purple "oxide colours." This was commonly attributed to oxidation by the absorption of air into cooling cracks in the pig, but I have seen many cases when these surfaces could only be broken apart by the most tremendous sledging, and this never seemed to me to correspond with the idea of a crack of sufficient width to permit the ingress of air.

the volume of the metal. The walls of these blowholes are as white as silver. The cause evidently is the descent into the hearth of a mass of incompletely reduced iron which, mixing with the liquid iron already present, sets up an action almost like that in an open-hearth furnace. The silicon is removed down to the barest trace, 0.03 per cent. or so, and the carbon is then attacked and oxidised from the normal 3.50 to 4.00 per cent. down nearly to 3.00 per cent. in some cases. The iron, being very cold and low in carbon, is naturally very pasty, and chills without giving a chance for the escape of the CO formed by the oxidation of the carbon. It was evident that this iron must contain a great quantity of oxygen and that if this were really the cause of strength, and the other desired qualities in iron it could be secured by making a mixture of this spongy No. 6 and a normal iron. Such a mixture was accordingly melted in the crucible, and test bars made therefrom showed results as strong or stronger than the best iron ever made from the furnace; 1.25-in. round bars on 12-in. centres breaking up nearly to 5,000 lbs., as against an average of about 3,000 lbs. for normal irons.

It then seemed that we had only to introduce

TABLE I.—*Results of Remelts.*

Original Iron. Cas No.	Kind.	Remelt No.	Breaking Strength pounds. 1.25 in. Round Bar.	2 in. Square Bar.	Total Carbon per cent.	Graphitic Carbon per cent.	Combined Carbon per cent.	Silicon per cent.	Manganese per cent.	Phosphorus per cent.	Sulphur per cent.	Nitrogen per cent.	Oxygen per cent.	Fracture.
A	Soft 1	—	3,000 3,530	—	4.00	3.22	0.78	1.90	0.62	0.139	0.017	0.006	0.027	Close grain for grade.
A	Soft 1	R. 291	3,150 3,200	16,000 15,900	4.05 4.05	3.40 3.05	0.65 1.00	Sample Sample	taken from 2 in. bar. taken from 1 in. bar.					
B	Spl. 1	—	2,500 2,900	—	4.09	3.43	0.66	1.88	0.70	0.112	0.020	0.003	0.009	Very open, low chill.
B	Spl. 1	R. 292	2,600 2,700	13,000 13,900	4.08 4.08	3.30 3.29	0.78 0.79	Sample Sample	taken from 2 in. bar. taken from 1 in. bar.					
C	High 2	—	3,400 3,500	—	4.00	3.05	0.95	1.00	0.46	—	—	—	0.038	Close grain, ¼ in. chill.
C	High 2	R. 297	3,800 3,700	16,000 15,000	3.96 3.96	3.00 2.96	0.96 1.00	Sample Sample	taken from 2 in. bar. taken from 1 in. bar.					
D	High 2	—	2,400 2,900	—	4.05	3.15	0.90	1.00	0.50	—	—	—	0.009	Open grain, no chill.
D	High 2	R. 298	3,000 2,800	14,900 12,000	4.13 4.13	3.00 3.16	1.13 0.97	Sample Sample	taken from 2 in. bar. taken from 1 in. bar.					
E	Med. 3	—	3,500 4,200	—	4.10	3.50	0.60	0.70	0.60	0.128	0.035	—	0.065	Very close grain. 0.25 in. chill.
E	Med. 3	R. 301	4,150	19,300 20,800	4.10	2.90	1.20	Sample	taken from 2 in. bar.					
F	Med. 3	—	2,500	—	4.49	3.60	0.89	0.72	0.59	0.108	0.024	—	0.009	Open grain, ¼in. chill.
F	Med. 3	R. 302	2,750	10,900 12,900	4.49	3.20	1.39	Sample	taken from 2 in. bar.					

It later occurred to me that we had disliked the "wild" coke irons because they were generally associated with high sulphur, without regard to their physical characteristics and on thinking it over, I realised that they were not infrequently exceedingly strong, tough irons; and, finally, it seemed to me likely that by reversing my former opinion absolutely we might perhaps get a theory which would conform more closely to the facts, and that it might be the presence of a certain amount of oxygen (in what form I do not pretend to say) that produced certain characteristics as to fineness of grain, chilling qualities, strength and toughness, which are so much desired. It is now more than two years ago since I began to work on this hypothesis with all the means at my command.

There is a product virtually unknown at coke furnaces, which we will call spongy No. 6. This is an iron made on an exceedingly cold furnace, perfectly white, and filled with a mass of blowholes so great as to occupy up to a half or even more of

oxygen into the hearth of the furnace to make an iron as good as the best. The easiest way to do this seemed to be to cause irregular working of the furnace, and this we proceeded to try by purposely distorting the filling for several hours. We undoubtedly upset the regular running of the furnace, but the iron was no better, probably somewhat worse than before. We then put a medicine valve on the bustle pipe, filled it with mill scale, and blew it into the hearth just before cast time, with little or no result, and such as there was, a detriment to the quality. This was repeated several times.

We then began ladle experiments, heating iron ore and other kinds of oxides in the bottom of a ladle before cast time and running iron in on them at cast, stirring up the mixture and pouring test bars and sample pigs. By this means we did close up the grain of the iron and induced a "paper" chill (that is, a line of white no thicker than a piece of paper around the edge of the pig), which was not present in the regular cast, but when it

came to improvement in strength and toughness there was little or none to be observed.

We first made a determination of oxygen in some spongy No. 6 and found it to contain as high as 0.13 per cent. We then took cold-blast irons and special cylinder irons and found these to range as high as 0.07 per cent. We then took normal charcoal irons and found them to contain only about 0.015 per cent.; foundry coke irons and electric-furnace irons contained none at all.

As many of the data in this article are derived from tests of re-melts, it seems desirable to state that all the re-melts mentioned or tabulated in this Paper are made in a "coke hole," approximately elliptical in shape, so as to take two crucibles at once, and provided with two tuyeres at opposite ends of its long diameter, so that both its crucibles would be subjected to the same intensity of combustion, etc. In all cases where directly comparative results of a given treatment have been sought, iron from the same cast has been used in each crucible, melted at the same time, and the two poured within a few minutes of each other; one with, the other without the desired treatment. We have endeavoured to get two 2-in. square bars, two 1-in. square bars, and two 1.25-in. round bars, all cast on end, from every such heat, but not having a skilled moulder on this rather difficult work, we have not always succeeded in getting a complete set of perfect bars. There is also, of course, a variation to be expected in these bars on account of the nature of the material and on account of their being industrial rather than laboratory or refined tests.

We repeated many times the experiment of re-melting normal or even very poor ("spotted") irons with spongy No. 6, and with the same result in every instance, an improvement in the strength up to 50 per cent. or more. In Table I. is given a summary of the results on the three pairs of re-melts mentioned earlier, which shows their chemical composition and also the strength of the original iron and of the re-melts. It will be seen that in every case those irons which were strong as they came from the furnace retained their superiority after remelting. The good iron was in each case much higher in oxygen than the corresponding poor iron.

To summarise, therefore, we consider that we have proved the following facts:—(1) Strong, tough irons of high chilling qualities contain oxygen in appreciable quantities. Weaker irons of similar analysis contain less or no oxygen. (2) Poor and normal irons may be improved beyond recognition by introducing oxygen into them.

As an additional proof that the actual cause of the increased strength of the strong irons was oxygen, we thought it would be well to try the effect of deoxidising some of these strong irons with recognised agents used for that purpose. We accordingly made various re-melts of strong irons which we deoxidised in the crucible immediately before pouring, with aluminium in several cases and with titanium in one or two. The results with titanium are confirmatory of the results with the aluminium. The strong irons deoxidised with about 1 oz. of 10 per cent. ferro-titanium per 50 lbs. crucible were greatly weakened. We believe that these results may be taken as a final and conclusive proof that oxygen in some form not known or understood by us is accountable for the abnormal strength of irons whose analysis as regards other elements is normal.

As to the condition in which this oxygen exists, we know nothing. We have been unable to detect it with the microscope, and we can only assume that it is some oxide of very much lower degree than any with which we are familiar. Its effects seem to be two-fold:—(1) It makes the iron very much more sensitive to chilling influences. One of these good irons if cooled normally will be only slightly harder than a normal iron, and on account of its fine, close grain will machine beautifully; but if the surface be chilled even slightly it begins to whiten up, and with a chill of any strength will be solid white at the edge, where a normal iron of the same silicon would show little chill, or none at all. (2) The other principal effect consists in the extremely fine subdivision of the graphite in the strong irons, contrasting conspicuously with the large, coarse aggregates of graphite in the weak irons. On comparing the photographs obtained of the strong irons with those of the malleable iron cast white and graphitised by annealing, one is struck with the resemblance, and it is easy to suppose that the effect of oxygen is to raise the solidifying point of the iron relative to the temperature of evolution of the graphite, so that the latter instead of being free in the liquid mass to assume as bulky a form as it chooses, can only form against great pressure, and must therefore form in the most compact particles possible, which, in turn, cannot coalesce into larger masses because of the resistance of the surrounding medium. These are purely scientific points outside the field of a commercial investigation, and beyond our power to investigate.

Conclusions.

Mr. Johnson's final conclusions are summed up as follows:—

(1) Irons which contain oxygen to a considerable extent, in a form as yet unknown, are stronger and tougher and have better chilling qualities than irons containing less of this element, but of the same analysis in other respects.

(2) Irons may contain a sufficient quantity of carbon to make them rotten and worthless through the predominance of the eutectic structure when deficient in oxygen, and yet, when they contain a considerable quantity of oxygen, may be entirely free from this structure and of excellent quality.

(3) Furnace conditions control whether the carbon shall be below or above the eutectic ratio and the presence of much or little oxygen, the two dominant factors in the fundamental quality of the iron; that iron, broadly, being the best which is made at the lowest temperature.

(4) Charcoal irons can be made at temperatures several hundred degrees lower than are practicable with coke, and have a great possible advantage in that respect. This is largely wasted without good furnace work in the broadest sense.

(5) Phosphorus up to 0.50 per cent. or more exercises a beneficial influence on the strength of the iron and the depth and character of the chill. Phosphorus also has a tendency to reduce total carbon.

(6) Aluminium and titanium tend to reduce the strength and chilling power of the iron by removing its oxygen, but titanium may have an influence independent of this on account of its also removing nitrogen.

(7) Chromium and manganese have an almost identical effect in raising the total carbon and throwing it into the combined condition. The latter increases the chill and the strength, but the combined carbon so produced is in the form of eutectic plates, which deprive the iron of much of the strength which it would have with the same combined carbon in the absence of these plates.

(8) Chill produced by these elements cannot be expected to have the same wearing qualities as that produced by elements which do not further the formation of flat plates of eutectic.

Causes of Strain in Castings.

Before the Birmingham Branch of the British Foundrymen's Association, on February 28, Professor T. Turner, M.Sc., Birmingham University, gave an illustrated lecture on "Strains in Cast Metals." Mr. C. Heggie (President of the Branch) was in the chair.

Professor Turner said that, of course, every one there was familiar with the fact that metals expanded when heated, and contracted on cooling. But in the case of the more useful alloys and varieties of iron the contraction on cooling was not uniform. There were marked irregularities or expansions while the metal was in the mould. In order to understand this one had to consider the co-efficients of expansion of the metals and their viscosity. Metals which melted at high temperatures had a low co-efficient of expansion, whilst conversely the more easily melted metals expanded more for the same rise in temperature. The imperfect metals expanded little whilst the non-metals had a very low co-efficient of expansion. The great fluidity of a metal at a temperature above its melting point was not perhaps fully realised even by those accustomed to dealing with metal under those conditions.

Dealing with the phenomena of solidification, Professor Turner took first the case of a substance which did not crystallise, because, he said, in the case of a crystallisable substance heat was given out during crystallisation, and that somewhat complicated matters. As examples of materials which did not crystallise at normal temperatures, they might take glass, a mixture of silicates which were mutually solid one with the other, or sealing wax, or crude paraffin wax. The purified paraffin, being one single paraffin, would crystallise, but a mixture of paraffin was a non-crystallising material. The cooling curve of a non-crystallisable material would contain no break, whereas that of a material which crystallised would have at least one distinct break, showing that the cooling had been interrupted. With regard to the substances which were considered as non-crystallising, the chemist would claim that such a substance did not really solidify, but was merely a supercooled material. His answer to that was that if he could hurt himself by knocking against a substance, or if it was sufficiently hard to scratch things, that substance was a solid; and it was not fair to use the term liquid for such a substance, whether it was crystallised or not. He preferred to speak of it as a solid, whatever its internal structure might be.

Such a material did not crystallise, but it gradually became solid, and it passed through stages, getting more and more viscid just as glass did. Glass, in fact, was a typical example; it was known that it could be blown and worked while red-hot, and how, as it cooled it gradually became harder and more brittle. It was the same with sealing-wax. Within the range of common temperatures it passed from the fluid state through the viscid state to one of brittle hardness. Taking a vessel filled with a substance of this character in the melted state, the temperature would gradually fall, the cooling being most rapid at the sides, and in a less degree at the top. The layer in contact with the sides of the vessel first became ropey or sticky, or viscid, and adhered to the sides of the vessel. It was not only rigid in itself, but it was also held by the walls of the vessel. The adjoining part of the material was still fluid, but it was cooling, though at a less rapid rate, and there was contraction. Thus the next layer contracted and also when it had solidified it was stuck to the first layer. The next layer behaved in the same way, and when the whole was cooled there would be the fall in the centre with which they were all familiar, and which was due to the fact that the outside layer became rigid, became attached and could not move, so that it retained its original level whilst the inside gradually sank and was drawn in to the side to fill in the space which was left owing to the contraction of the mass as a whole.

A material that did not crystallise no matter how cold it was made, was always brittle. At what the practical man would call the state of solidification it would be brittle and hard, and that was a characteristic of all these metastable bodies. They were not really stable because if they were given sufficient time they would crystallise and separate out. But when they had been cooled gradually they were in a state of high strain, which meant that they were hard and brittle. The outer part was so strained over the inner part that the least tap would cause them to crack. They had an example of this in the scientific toy known as Prince Rupert's drops. This increase of hardness was not only true of glass and similar substances which remained in solution, but had a tendency to separate; it was also true of all solid solutions, even when there was crystallisation. For instance, the ordinary rolling brass was a solid solution of zinc in copper, the hardness of which was greater than the mean hardness of the constituents of the alloy. That was the general rule with all solid solutions.

The lecturer next discussed the case of crystallisable substances, to which the majority of the useful metals and alloys belonged. When solid solutions crystallised they gave a uniform mixture of similar crystals, the German name for which had been translated into English as "mixed crystals." Every substance which crystallised had in its cooling curve a sudden arrest when it became solid. During crystallisation heat was evolved. In the majority of metals the form of the crystals was of the type known as cubic. The crystals formed by some kind of mutual molecular attraction, the nature of which was not fully understood. The cubical system among crystals had a great many variations. There might be crystals with twelve, twenty-four, and even more faces, but the usual form derived from the cube was the octahedron or eight-sided, and they might assume that the octahedron played an important part in the crystallisation of metals. Crystals grew from the outside of the mass and met in the middle, with the result that there were lines of weakness at every corner. All founders should remember that wherever there was a sharp edge there was always likely to be a line of weakness. A series of slides was shown illustrating the process in the arrangement of crystals known as parallel grouping, which led to the formation of the compound octahedral form and ultimately to the structure which resembled a fir tree, and was known as the dendritic structure. In brass, steel and most of the common metals, said the lecturer, that type of structure was got. There were some metals which crystallised in the hexagonal form, but they were not of importance to the founder. The dendritic structure might often be observed in a steel ingot by looking at the cavity due to piping; or in cast iron in a bear which had been formed in the blast furnace. An example of this was illustrated on the screen.

Having dealt with the phenomena of crystallisation in various metals and alloys, Professor Turner said that there was one very important matter to be remembered in connection with the separation of constituents, and that was the rule which physicists called the phase rule. It was perhaps rather difficult for the practical man to understand, but there was only one thing about it which ironfounders need remember. The phase rule told them that with a falling temperature only one material could separate out at one time. Suppose the temperature to be falling, with a complex material like cast iron, the carbon might be separated as graphite or as carbide; there might be phosphide of iron or a solution of manganese and iron, or iron silicide, or manganese sulphide and perhaps other things, especially if the iron happened to be of unusual composition. Now, it did not matter how many things there were in that mixture, if it were allowed to cool slowly all would separate out in order, one constituent at a time—not necessarily one element, but one phase, one substance at a time. The different constituents did not separate out, as used to be imagined, side by side, at the same time, but if the constituents were given time to carry out their own will the different substances would come out in a definite sequence.

With regard to the effect of the size and shape of the casting from the point of view of the strain which was set up during cooling, the first thing that was known in reference to the shape was, that since the crystals grew from the outside inwards, there was naturally somewhere a point of weakness. The next thing was that the larger the object the more slowly it would cool, other things being equal; therefore, the larger the crystal, the softer the material and the weaker it would be. In illustration of what would happen with a variation of time of cooling, the lecturer took the case of an iron casting in the form of a square and having a thickness of, say, one inch with bars across it three-eighths of an inch thick forming a grid (Fig. 1). Obviously the bars being smaller would cool much more quickly. The result was that they would contract at a very much more rapid rate than would the metal forming the frame. The co-efficient of expansion was the same in both cases, and both had to go through the same changes while cooling. That being so, if anything abnormal should arise in the shape of expansion, a difficulty would arise at once in a casting such as that. Foundrymen, of course, were aware of the difficulty arising from these differences in size, and in practice would take means to counteract it. For instance, they would probably expose the larger piece so as to make it cool more quickly, or in some cases would put in a chill, or a water-cooling arrangement, the object being to make the mass as a whole cool more uniformly and thus by diminishing the strains making a much sounder casting.

Now, with the majority of the alloys not merely an effect such as that to which he had just referred—the uniform contraction in each direction—had to be considered; in almost all the practical alloys used by the founder there were changes which took place at intervals below the solidification point. Cast iron expanded after solidifying, but that was not at all exceptional. Water was another instance. It was not known definitely what took place when water solidified, but it was known that an expansion took place, and, if they could accept Professor Armstrong's explanation, it meant that there were aggregations of large molecules, and these aggregations took another form which occupied more space, and in this way there was expansion. The first man who experimentally recorded what took place in alloys after solidifying was Keep. As far as the lecturer knew, no one had previously endeavoured to trace continuously the very important things that went on as a metal came down to the temperature of the air, until Keep experimented. That investigator found that instead of having a uniform cooling curve such as one might have expected, different kinds of metal differed in their behaviour. In some cases the curve became nearly horizontal, which meant that there was very little change of volume for minutes after the metal had been poured. Keep showed also that the first expansion corresponded with the separation of the primary or coarse graphite, whilst the second corresponded with the separation of phosphorus, there being no expansion at this point if phosphorus were not present, and that the third expansion corresponded with the separation of secondary or fine grade graphite at a lower temperature.

There was a moderate expansion at the moment of solidification, and that might be due to a certain amount of crystal thrust, or it might be a retardation of the rate of contraction by heat being given out while crystallisation was taking place. With wrought iron there was no arrest; with steel there was an arrest corresponding exactly with the recalescence due to the throwing out of the carbon in cast iron. With a grey hematite there were two expansions, due to the formation of primary and secondary graphite. A grey iron containing phosphorus, say 1.2 to 1.5 per cent. showed three expansions, and at the end of five minutes cooling in the mould the bar would have practically the same

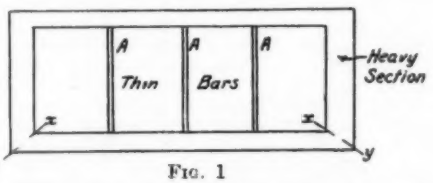


FIG. 1

volume that it had at the beginning of that period. Of course, such a metal filled the mould very well; it took very sharp impressions and came out beautifully clean, and not quite so much allowance for shrinkage in the mould would have to be made with that metal as with a hard iron. If the grid casting before mentioned were made of this metal, before the thicker part had begun to contract the thinner part would have contracted and expanded three times. The coarser the graphite and the more phosphoric the material the greater would be these expansions, and therefore the more trouble would be experienced in making a casting of that sort. The same action would take place in casting a wheel with the spokes much thinner than the other part.

In the case of aluminium and its alloys, there had been little difficulty, so far as he knew, with regard to irregular contraction. Although there was a large expansion there were no irregularities after once the metal had solidified. Aluminium behaved very curiously just for a few moments, but it did not give a single definite temperature arrest in solidifying. It generally gave two arrests, but only during the very first few moments, and then it went on quite uniformly. Some of the aluminium alloys, those in common use which were of very simple composition, were also free from irregularities. On the other hand, all the zinc-copper alloys showed irregularities of expansion, and he knew that manufacturers sometimes had difficulties with these alloys in preventing fractures. The expansion curve of the aluminium-zinc series was a straight line for the useful alloys, so that there should be little or no difficulty in casting with these alloys. He would

not, however, venture to prophesy that with aluminium alloyed with zinc, copper, or any other of the materials which were put in to give strength, they would never have trouble. It was always dangerous to prophesy from scientific experiments exactly what would happen in the foundry.

He had endeavoured to explain the stresses in cast metal. On the one hand, when there was a certain amount of metastable contents in the mass, the substance was more or less viscid, and so the exterior as it cooled would naturally become brittle, whilst the interior would cool at a different rate, and there would be layers super-imposed one against the other each in a state of strain. That was what happened in the harder alloys. In the softer alloys there were very commonly several constituents which separated out in order, one after the other, and when each of the constituents separated there was a volume change, usually an expansion, when something was thrown out of solution. The expansion was one involving considerable force. Therefore, the object of annealing would be appreciated. Annealing allowed of the diffusion of the various constituents which were present in the alloy. For example, in the case of a copper-zinc alloy, where the cores or the centre crystallites were richer in copper than was the outside, annealing for a sufficient length of time would cause the material to diffuse and so the alloy would become perfectly uniform in composition. It was very much the same in reference to steel, only in that case the object was rather to throw the

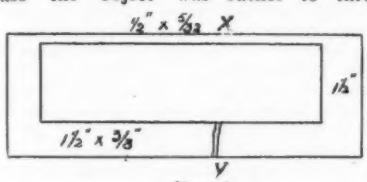


FIG. 2.

carbon out of solution, because if it were kept in solution it would be in a metastable condition, whereas by throwing it out of solution they would avoid this condition and yet have the carbon uniformly distributed through the mass.

Discussion.

The PRESIDENT said he was particularly interested in some of the cooling curves shown, especially those referring to cast iron. Regarding experiments made respectively by Professor Turner and Keep, the former with ½-in. square bars and the latter with 1-in. square bars, both bars clearly showed three expansions, but after 12½ to 14 minutes the 1-in. bar had only reached its third expansion, and even after 17 minutes the casting was only then back to the original size of the mould or pattern, while with the ½-in. bar, this, he believed, was reached in 4½ minutes, a difference of 12½ minutes. It was not difficult to imagine castings with irregularities of design equal to those quoted, and whilst admitting, of course, that such variations from a casting were different from those to be observed on two bars cast separately, still he felt that it was possible to have castings in which one part might be contracting from the height of its third expansion while another part might be expanding towards its third expansion. He had seen this expansion actually taking place in the mould and had roughly timed some of the points. The casting under observation was a simple frame (see Fig. 2). Five seconds were taken up in pouring and the top part of the box was lifted off one minute after pouring had been started. At this time the centre X of the narrow bar was a very dark red, and it was soon black. Forty seconds later, contraction was noticed at the end of this bar, but none was seen at the end of the wide bar Y until two minutes more had elapsed. Fifty seconds later, expansion was seen to begin on this bar, and it could be plainly seen that the edges of the mould were being pushed back. No further contraction was seen until five minutes after the first contraction had been noticed. No expansion was observed on the thin bar, which continued to contract. He thought they were misled sometimes by being told that light sections contracted more than heavy ones. Of course, he did not mean to suggest that this was not so when the sections were separate castings, but he felt that it was not always so when they were part of one casting. Looking at this same frame again, if the thin bar contracted more it should be in a state of tension, but they would find that it was usually in compression, and if it were fractured at the centre X the broken ends would overlap. If the wide bar was broken, it would spring apart as at Y, being pushed out by this thin bar. Whilst admitting, of course, that the thin bars at A (Fig. 1) would cool first, it must be remembered that while cooling they were being fed from the heavy section, sucking the metal away from it as they cooled. As the heavy section cooled down and contracted it was more than likely that the thin bars, as in the other diagram, would be put in a state of compression tending to burst the casting along the lines *x—y*.

MR. F. JOHNSON, referred to the viscosity of molten copper at a few degrees above the melting-point and the differences which the addition of some substances would make. Phosphorus, for instance, engendered fluidity, whereas aluminium would increase the viscosity of the copper so that instead of pouring out like water it was more like custard. This was due to the formation of a film of oxide which became entangled in the molten metal and prevented the metal from having that fluidity which was desirable. One thing that Professor Turner did not draw out as the speaker had expected he would, was the effect of the presence in castings of constituents, the co-efficient of contraction of which differed from that of the body of the metal in which they were contained. Take, for instance, a bronze containing at least two very different substances. The main body of the metal would contract at a different rate from the other substance, and the natural result of that was that cavities would be formed. He remembered some time ago having to deal with a Muntz metal containing an impurity which had the ability to form intercrystalline films which were not visible under the microscope because they were so exceedingly small, but which had the property of separating out round the crystals and bringing out and intensifying the structure which Professor Turner had shown in the case of white iron—a coarse crystallisation at right-angles to the surface. In this particular ingot the effect was so marked that in solidifying crystals were formed from either side practically parallel to the bottom of the mould, and they were found to have arranged themselves so as to meet at a plane down the centre of the ingot. That was a case in which these inter-crystalline films had caused a fracture almost to take place without the application of force. The metal if it had not possessed these impurities would have been much tougher. One point in Professor Turner's remarks which had struck him was the expansion in cast iron due to the phosphide eutectic. He did not think Professor Turner wished them to infer that that expansion was due to the actual volume change of the phosphide eutectic; that the phosphide eutectic was at that point of greater volume than it had been before. It struck the speaker as being rather a peculiar phenomenon, however, and he would be

very glad if Professor Turner would give them an explanation as to the effect of the phosphide eutectic on the separation of graphite, and whether at that particular moment graphite was a constituent of the eutectic or not.

Mr. F. C. A. H. Lantsberry remarked that Professor Turner had shown in a striking manner how difficult it was to make a sharp line of demarcation between liquids and solids. In the same way there was no abrupt change from the gaseous to the liquid state. The three states of matter, solid, liquid, and gas, were perfectly continuous. An amorphous material could be cooled down until the viscosity became too great for it to flow freely, but there was no line of demarcation in that case between the liquid and the solid. That view was borne out by the fact that very often this amorphous material when it crystallised underwent a considerable change in volume and very often broke down altogether. It was very important in distinguishing between amorphous and crystalline material that one should have a clear idea of how these materials crystallised. Professor Turner had shown them how the material began to crystallise from a number of nuclei to form grains, and he would ask whether Professor Turner considered each grain as a single crystal or as a conglomerate of smaller crystals. Among Professor Turner's expansion experiments there was one very interesting thing. The expansion of the aluminium-zinc alloys had been shown on the same slide with the equilibrium diagram of that series obtained by Shepherd, but at one point Professor Turner showed a certain expansion which did not correspond to anything on the thermal curve. The revised equilibrium diagram by Rosenhain and Archbutt showed that aluminium and zinc formed a compound corresponding pretty closely with the sudden expansion observed by Professor Turner.

Mr. H. James Yates, said it was a great pleasure to him to see so many men actively engaged in foundry work, taking such a deep interest in the problems and difficulties which Professor Turner had discussed before them. He only wished that a greater number of men would take advantage of Technical Schools. He was particularly interested in what had been said in regard to the original work of Mr. Keep. It had been his good fortune to meet Mr. Keep in his foundries in Detroit some years ago, and since his return from America they had been able to take great advantage of the experience gained by Mr. Keep in his original work.

Mr. R. Buchanan said that the sketch of a wheel which Professor Turner had drawn on the board had excited his curiosity, because he had sometimes tried to picture to himself the expansions and contractions which took place in casting a flywheel, and had tried to puzzle out exactly what the effects would be. He had come to the conclusion that some of the things which were called liquid contraction arose from expansion taking place in other parts of the casting. He would be very much interested if Professor Turner would give them his idea as to the sequence of expansions and contractions which took place in the ordinary form of flywheels with a heavy rim, and a heavy hub and comparatively light arms. The lecture had been very interesting, and although many of them had seen some of these things before, it was profitable that they should have them constantly brought under their notice, because they were things of such great importance in all foundry operations.

Professor Turner, in his reply, said that one gentleman had asked him what was the cause of the expansion that took place on the separation of the phosphorus eutectic. He could only answer that he did not know. But there was an expansion, and it was always accompanied by the presence of a phosphorus eutectic. Several explanations had been suggested, but he had not been able to prove them. It was known that when one phase separated from the mass heat was evolved. That would give expansion, but whether the expansion would be larger than the ordinary expansion due to the heat itself it was difficult to say. If only heat was given out, the ultimate expansion should be the same, whether phosphorus eutectic separated or not. But as a matter of fact the ultimate shrinkage was larger in the absence of phosphorus than when phosphorus was present. He was inclined to think that it was due to the re-arrangement of the molecules. If the graphite separated from the iron and the flakes grew in size, it required more space, and the same was true with the phosphorus. But it did not necessarily follow that all material required more space when it separated, because it might crystallise in such a form that the whole number of crystals would occupy a less space. In one of the examples he had shown them there was no re-arrangement because all the crystals that were formed were well packed cubes and required less space. It was not only in the compounds that this expansion was observed, but also in the simpler mixtures. In all the allotropic forms there was a change of volume. Mr. Heggie had asked him whether he considered a crystal grain to be a true crystal. He did not consider a crystal grain to be a crystal. It was simply something in the form of a box; a number of the smallest form of crystals were packed together, and round the outside there was formed a liquor which Dr. Rosenhain called an amorphous residue, but which might be the most fusible constituent, and yet be very brittle. He was pleased that Mr. Lantsberry had mentioned the fact that the equilibrium diagram of the aluminium-zinc series had been revised, and that they could now account for the apparent anomaly of the expansion curve. Although he did not claim that they could ascertain the equilibrium diagram from the expansion, he did claim that they were able to find a connection between the expansion and that which was represented on the equilibrium diagram. What he meant was that though one could not find the whole of the equilibrium diagram following the expansion curve, the expansion curve would show something of what would be found on the equilibrium diagram. It showed part of it, if it did not show all. Mr. Buchanan had spoken about a flywheel. What would happen depended a good deal upon the size of the flywheel and the proportions of the different parts, whether the hub was small or large, the size of the spokes, and the thickness of the rim, also upon whether artificial cooling was applied to any of the parts. The question had been asked whether the spokes in case of unequal cooling would be in tension or in compression. He had never known the spokes show any signs of compression; their method of fracture always rather gave him the impression that they were in tension, and if that was so, that was a partial answer at all events to Mr. Buchanan's question.

Mr. Buchanan remarked that with regard to phosphorus he once suggested in the presence of Dr. Stead that the expansion was due to the formation of phosphide eutectic. Afterwards, in the course of his reply, Dr. Stead corrected him and said that it was due to the solidification of the phosphide.

Professor Turner: When I say separation I mean solidification, because it does not separate without being solidified.

A hearty vote of thanks to the lecturer concluded the meeting.

Nomenclature of Alloys.*

The committee wish particularly to emphasise that they have not approached this matter in any academic spirit, but have endeavoured to bear in mind in the first place the needs of industry and commerce. Had they merely wished to draw up a system of nomenclature for the use of scientific men, their task would have been much easier, since practical and commercial considerations are responsible for the more serious difficulties to be overcome in this matter.

Careful consideration of all the numerous suggestions received has led the committee to adopt certain guiding principles in the conduct of their work. These may be briefly stated as follows:—

(1) So far as names intended for use in industrial and commercial practice are concerned, it is desirable to adhere as far as possible to existing names sanctioned by long usage, provided that all such names can be so defined as to avoid all risk of confusion or ambiguity.

(2) The coining of new names or the adoption of recently coined names not in general use should be avoided as far as possible.

(3) It is desirable to employ simple English names throughout, avoiding the use of Latin or foreign names, and of chemical or other symbols.

From the principles laid down above it follows that the task before the committee resolved itself into that of framing rational definitions of the more widely used alloy names. In order to accomplish this in a satisfactory manner the committee have found it desirable to establish in the first place a rational or systematic nomenclature based upon some completely general principle. Such a system of nomenclature would probably be too cumbersome for general use, and would depart too widely from ordinary usage to be satisfactorily employed for industrial or business purposes. Its main object, apart from possible use by scientific writers, is to serve as a basis for the definition of what may be called "practical names." The committee have, in fact, aimed at defining practical terms as simple abbreviations of the systematic names of alloys.

The only principle of sufficiently wide applicability upon which they can base a rational or systematic nomenclature is that of naming alloys according to their chemical composition by weight. Although there are cases of some difficulty even under this principle, the fact remains that every alloy possesses a definite and definitely ascertainable composition by weight, and that—speaking in the most general terms—the properties of alloys are more universally dependent upon their chemical composition than upon any other single factor of general importance.

The principle which the committee has adopted for the construction of a system of nomenclature on the basis just indicated is that of denoting any alloy by the names, in English, of its component metals, placed in the order of increasing numerical importance from the point of view of chemical composition by weight. In adopting this order for the names of the component metals, the committee have endeavoured to follow existing usage as closely as possible, although existing practice in this respect is not uniform. Thus "phosphor-copper" follows the order adopted by the committee, while "cupronickel" does not. As examples of what is implied by the principle adopted for the construction of systematic names for alloys, a few instances may be useful, in which the approximate composition of some typical alloys is stated, together with the corresponding "systematic" name.

Composition of Alloy.	Systematic Name.
Zinc, 30 per cent.; copper, 70 per cent. ..	Zinc-copper.
Tin, 10 per cent.; copper, 90 per cent. ..	Tin-copper.
Tin, 1 per cent.; zinc, 29 per cent.; copper, 70 per cent.	Tin-zinc-copper.
Aluminium, 8 per cent.; copper, 92 per cent.	Aluminium-copper.
Copper, 3 per cent.; aluminium, 97 per cent.	Copper-aluminium.
Tin, 32 per cent.; lead, 68 per cent. ..	Tin-lead.

It will be seen that although this system is perfectly simple and rational, this simplicity is accompanied by a considerable degree of cumbrousness when alloys of more than three metals are to be described. A difficulty also arises with regard to the question of impurities present in notable amount, and another obstacle is found in the case of alloys in which two or more metals are present in practically equal proportions. The committee have considered these difficulties, and propose the following methods of dealing with them:—

(1) Where an alloy consists of more than three metals its systematic name shall not as a rule contain more than the names of three metals present in the largest proportion by weight, but the presence of additional metals or elements shall be denoted by the prefix "comp." or "complex." If, however, an alloy of this kind contains an intentionally added element which, although present in small quantity, gives the alloy a distinctive character, that element may be named first. To take an imaginary example, if an alloy containing aluminium 75 per cent., tin 15 per cent., arsenic 4 per cent., cobalt 3 per cent., iron 2.75 per cent., and (say) indium 0.25 per cent., owed its (supposed) special qualities to the presence of the last-named element, it would be denoted as "indium complex tin-aluminium." This is obviously an imaginary case of a very extreme type, and is given merely to illustrate the principle. The resulting name is still decidedly cumbersome, but not too much so for the purposes of a systematic nomenclature which is not intended for general practical use.

(2) As regards impurities present in notable quantities, the committee have reached the conclusion that since the question of drawing up specifications for the proper composition of alloys lies outside their province, and is, moreover, governed by entirely different considerations and conditions, the present committee cannot lay down any rules as to the quantities of "impurities" which may be admitted without reference in the name of the alloy. When standard specifications are available this point will be automatically decided. Meanwhile, the committee recommend that in the systematic names as here defined reference should be made to all elements whose presence in the alloys in notable quantities is *intentional*.

(3) With regard to alloys which contain two or more metals in equal or nearly equal quantities, the committee recommends that the principle should be followed that where no numerical preponderance is established the metals should be placed in alphabetical order.

Having thus established what they believe to be as simple and rational a system of names as any

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very glad if Professor Turner would give them an explanation as to the effect of the phosphide eutectic on the separation of graphite, and whether at that particular moment graphite was a constituent of the eutectic or not.

Mr. F. C. A. H. Lantsberry remarked that Professor Turner had shown in a striking manner how difficult it was to make a sharp line of demarcation between liquids and solids. In the same way there was no abrupt change from the gaseous to the liquid state. The three states of matter, solid, liquid, and gas, were perfectly continuous. An amorphous material could be cooled down until the viscosity became too great for it to flow freely, but there was no line of demarcation in that case between the liquid and the solid. That view was borne out by the fact that very often this amorphous material when it crystallised underwent a considerable change in volume and very often broke down altogether. It was very important in distinguishing between amorphous and crystalline material that one should have a clear idea of how these materials crystallised. Professor Turner had shown them how the material began to crystallise from a number of nuclei to form grains, and he would ask whether Professor Turner considered each grain as a single crystal or as a conglomerate of smaller crystals. Among Professor Turner's expansion experiments there was one very interesting thing. The expansion of the aluminium-zinc alloys had been shown on the same slide with the equilibrium diagram of that series obtained by Shepherd, but at one point Professor Turner showed a certain expansion which did not correspond to anything on the thermal curve. The revised equilibrium diagram by Rosenhain and Archbutt showed that aluminium and zinc formed a compound corresponding pretty closely with the sudden expansion observed by Professor Turner.

Mr. H. James Yates, said it was a great pleasure to him to see so many men actively engaged in foundry work, taking such a deep interest in the problems and difficulties which Professor Turner had discussed before them. He only wished that a greater number of men would take advantage of Technical Schools. He was particularly interested in what had been said in regard to the original work of Mr. Keep. It had been his good fortune to meet Mr. Keep in his foundries in Detroit some years ago, and since his return from America they had been able to take great advantage of the experience gained by Mr. Keep in his original work.

Mr. R. Buchanan said that the sketch of a wheel which Professor Turner had drawn on the board had excited his curiosity, because he had sometimes tried to picture to himself the expansions and contractions which took place in casting a flywheel, and had tried to puzzle out exactly what the effects would be. He had come to the conclusion that some of the things which were called liquid contraction arose from expansion taking place in other parts of the casting. He would be very much interested if Professor Turner would give them his idea as to the sequence of expansions and contractions which took place in the ordinary form of flywheels with a heavy rim, and a heavy hub and comparatively light arms. The lecture had been very interesting, and although many of them had seen some of these things before, it was profitable that they should have them constantly brought under their notice, because they were things of such great importance in all foundry operations.

Professor Turner, in his reply, said that one gentleman had asked him what was the cause of the expansion that took place on the separation of the phosphorus eutectic. He could only answer that he did not know. But there was an expansion, and it was always accompanied by the presence of a phosphorus eutectic. Several explanations had been suggested, but he had not been able to prove them. It was known that when one phase separated from the mass heat was evolved. That would give expansion, but whether the expansion would be larger than the ordinary expansion due to the heat itself it was difficult to say. If only heat was given out, the ultimate expansion should be the same, whether phosphorus eutectic separated or not. But as a matter of fact the ultimate shrinkage was larger in the absence of phosphorus than when phosphorus was present. He was inclined to think that it was due to the re-arrangement of the molecules. If the graphite separated from the iron and the flakes grew in size, it required more space, and the same was true with the phosphorus. But it did not necessarily follow that all material required more space when it separated, because it might crystallise in such a form that the whole number of crystals would occupy a less space. In one of the examples he had shown them there was no re-arrangement because all the crystals that were formed were well packed cubes and required less space. It was not only in the compounds that this expansion was observed, but also in the simpler mixtures. In all the allotropic forms there was a change of volume. Mr. Heggie had asked him whether he considered a crystal grain to be a true crystal. He did not consider a crystal grain to be a crystal. It was simply something in the form of a box; a number of the smallest form of crystals were packed together, and round the outside there was formed a liquor which Dr. Rosenhain called an amorphous residue, but which might be the most fusible constituent, and yet be very brittle. He was pleased that Mr. Lantsberry had mentioned the fact that the equilibrium diagram of the aluminium-zinc series had been revised, and that they could now account for the apparent anomaly of the expansion curve. Although he did not claim that they could ascertain the equilibrium diagram from the expansion, he did claim that they were able to find a connection between the expansion and that which was represented on the equilibrium diagram. What he meant was that though one could not find the whole of the equilibrium diagram following the expansion curve, the expansion curve would show something of what would be found on the equilibrium diagram. It showed part of it, if it did not show all. Mr. Buchanan had spoken about a flywheel. What would happen depended a good deal upon the size of the flywheel and the proportions of the different parts, whether the hub was small or large, the size of the spokes, and the thickness of the rim, also upon whether artificial cooling was applied to any of the parts. The question had been asked whether the spokes in case of unequal cooling would be in tension or in compression. He had never known the spokes show any signs of compression; their method of fracture always rather gave him the impression that they were in tension, and if that was so, that was a partial answer at all events to Mr. Buchanan's question.

Mr. Buchanan remarked that with regard to phosphorus he once suggested in the presence of Dr. Stead that the expansion was due to the formation of phosphide eutectic. Afterwards, in the course of his reply, Dr. Stead corrected him and said that it was due to the solidification of the phosphide.

Professor Turner: When I say separation I mean solidification, because it does not separate without being solidified.

A hearty vote of thanks to the lecturer concluded the meeting.

Nomenclature of Alloys.*

The committee wish particularly to emphasise that they have not approached this matter in any academic spirit, but have endeavoured to bear in mind in the first place the needs of industry and commerce. Had they merely wished to draw up a system of nomenclature for the use of scientific men, their task would have been much easier, since practical and commercial considerations are responsible for the more serious difficulties to be overcome in this matter.

Careful consideration of all the numerous suggestions received has led the committee to adopt certain guiding principles in the conduct of their work. These may be briefly stated as follows:—

(1) So far as names intended for use in industrial and commercial practice are concerned, it is desirable to adhere as far as possible to existing names sanctioned by long usage, provided that all such names can be so defined as to avoid all risk of confusion or ambiguity.

(2) The coining of new names or the adoption of recently coined names not in general use should be avoided as far as possible.

(3) It is desirable to employ simple English names throughout, avoiding the use of Latin or foreign names, and of chemical or other symbols.

From the principles laid down above it follows that the task before the committee resolved itself into that of framing rational definitions of the more widely used alloy names. In order to accomplish this in a satisfactory manner the committee have found it desirable to establish in the first place a rational or systematic nomenclature based upon some completely general principle. Such a system of nomenclature would probably be too cumbersome for general use, and would depart too widely from ordinary usage to be satisfactorily employed for industrial or business purposes. Its main object, apart from possible use by scientific writers, is to serve as a basis for the definition of what may be called "practical names." The committee have, in fact, aimed at defining practical terms as simple abbreviations of the systematic names of alloys.

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It will be seen that although this system is perfectly simple and rational, this simplicity is accompanied by a considerable degree of cumbrousness when alloys of more than three metals are to be described. A difficulty also arises with regard to the question of impurities present in notable amount, and another obstacle is found in the case of alloys in which two or more metals are present in practically equal proportions. The committee have considered these difficulties, and propose the following methods of dealing with them:—

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that could be devised in the circumstances, the committee have approached the task of defining, in terms of the systematic or rational names, the ordinary names of alloys intended for everyday usage. The principle which the committee have adopted is that of defining a few of the best-known and most widely used terms simply as definite abbreviations or contractions for certain names or groups of names in the systematic nomenclature.

The committee having in the first instance confined their attention to the alloys of copper, the terms first defined on this basis are "brass" and "bronze." The definitions recommended and adopted by the committee are as follows:—

Brass.

The term "brass" is to be used as an abbreviation of the word "zinc-copper" as employed in the systematic nomenclature. Thus when the word "brass" alone is employed it shall denote an alloy of zinc and copper only, containing more copper than zinc, i.e., containing over 50 per cent. of copper. When an alloy containing a third metal, such as tin, is to be denoted, the name of the additional element shall be used as a prefix, precisely as in the systematic nomenclature. Thus an alloy containing tin 1 per cent., zinc 29 per cent., and copper 70 per cent., would be called "tin-brass." If additional metals are present their names may also be prefixed, or the general prefix "comp." or "complex" may be used if it is not essential to mention the other elements specifically.

Bronze

The term "bronze" is to be used as an abbreviation of the words "tin-copper" as employed in the systematic nomenclature. Thus when the word "bronze" alone is employed it shall denote an alloy of tin and copper only, containing more copper than tin, i.e., containing more than 50 per cent. of copper. The presence of one or more additional metals shall be denoted in the same manner as has been indicated above in the case of "brass."

The committee is not prepared at the present stage of its work to recommend definitions of any further practical terms, as further consideration is required for the framing of definitions relating to smaller and more strictly limited classes of alloys.

Moulding from Plaster Blocks.

By A. H. H.

This is one of the cheapest methods of making castings in quantities, especially if required at short notice. It is also one whereby the smaller foundries may compete with the larger ones in the production of small castings, and one that is useful to the large foundries in the making of isolated orders, or where there is no time to cast and finish off a pattern-plate, as these blocks can be made, castings made from them and sent away, long before they could be made from loose pattern or a pattern-plate got ready. The method of making these blocks is as follows, taking a small bracket for example (Fig. 1). Sufficient patterns are made and filed up to go into the size of box selected, and in each pattern holes are drilled and tapped, the size of tap used being a ¼ in.

For patterns having a flat surface, such as these, a flat board, or better still a planed plate to fit the size of box, is used to ram the patterns on, but if the surface is irregular, an odd-side is rammed off the flat plate and the patterns set on that, care being taken to set them square with each other and also square with the face of the box.

The patterns are then proceeded with as if the castings were being made, but the patterns are not withdrawn from the sand, and care is taken in making the runners. The whole of the joint face is then dusted with plumbago and carefully sleeked to make a nice smooth joint, as in the case of making a pattern-plate. Each core is then covered with a thin sheet of iron or tin, sometimes glass being used, thin glue or core-gum being put on to secure them from being washed away by the flow of plaster. This is done so that if it is necessary to clean the core hole no damage is done to the plaster.

Screws are then put into the holes, each screw having a washer attached under the head. This is done by wrapping paper round till the washer fits tight, the length of screw being determined by the thickness of the blocks, which are kept as light as is possible to work them.

Each part is then fitted with spare parts, and plaster mixed and poured into them, a good mixture being about 8 parts of plaster to 1 of fine parting sand mixed dry. After they have stood long enough to get sufficiently hard, they are removed and the sand cleaned from them with a brush, then clean water is employed to wash away traces of sand and plumbago, and they are allowed to dry, then given a coat or two of clear varnish.

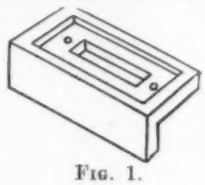


Fig. 1.

When this is dry they are ready for use, that is if good plaster has been used; if not, they will have to be stoved before varnishing.

The method of moulding from them is as follows:—The cope is put on the floor and the drag rammed off it, turned over and drawn just as in plate-moulding; then the cope is rammed and the drag covered in, the best way being to ram all the drags first and then the copes afterwards.

From this description it may look to be a lengthy process, but an intelligent moulder will soon get in the way of making these blocks; the writer has made them in less than two hours, and they have had hundreds of castings made from them the same day. Of course, care has to be taken in using them, but with proper usage they will last a long time, and if repeat orders are likely to be given they can be stored away till wanted again.

Tests of Cast Iron.

In the course of the discussion on the paper on "Cast Iron for Machine-Tool Parts," submitted recently by Mr. Henry M. Wood to the American Society of Mechanical Engineers, and which was published in abstract in our issue of February, Professor Jenkins described tests which were conducted at the plant of Alfred Herbert, Limited, of Coventry. In these tests, cast-iron blocks, after having been finished off, were rubbed across each other a distance of 84 miles by actual measurement. One of these blocks was of soft iron and the other of hard iron; the soft block showed far greater wear resistance than the hard block. Mr. Bradley Stoughton discussed Mr. Wood's paper at considerable length and announced that there would be made public shortly a report regarding a new mixture of cast iron which is far superior to malleable iron.

Casting in Metallic Moulds.

By Walter J. May.

Making castings in metallic moulds is not at all a new process, although during the last few years it has been developed on somewhat new lines, and is being still further developed in places where large numbers of identical castings are needed. Probably, with some limitations in regard to size, firms making articles with parts which are interchangeable will eventually use these permanent iron moulds very largely, especially as with a little care there need be only the minimum of machining done to the castings, this making it possible to turn out sufficiently finished castings for many things. In the cheaper classes of goods turned out by the thousand, the production of cast parts practically finished is of much importance, owing to the fact that the less the things are handled the lower their first cost can be kept.

It will usually be found that to ensure economy in production the cost of plant will be somewhat heavy when its first installation alone is considered, but the saving in cost of manipulation afterwards gives a large ultimate profit. It is in this way that American practice enables makers to cut prices very largely, because in the first place work is standardised, and as far as possible interchangeable, thus reducing numbers of parts; then the best appliances for turning out the parts are obtained, no hesitation being shown in scrapping an appliance if a better can be had, and what is quite as important, wages rather rise than fall as the various appliances are introduced. In the case of permanent-mould making, the makers of the moulds are well paid, and for this reason the mould is costly, but as against this must be set off the low cost in producing castings from the moulds, as even against the best machine moulding there is a large reduction both in cost and time. Supposing a mould costs £1 and produces 1,000 good castings, the cost of moulding runs out to approximately a farthing per casting, as against from 6d. to 9d. by hand work, and the castings being to all intents and purposes identical in size and form, they can be very economically handled in the machine rooms. As against these reductions there is probably a small increase in the cost of working the moulds, this being dependent on the organisation of the moulding floor, but when worked in series in a systematic manner, and with a continuous running cupola or a battery of crucible furnaces of a size to keep up continuity of working, the increased cost of manipulation can be kept down to quite a small thing. One or two moulds only would be a nuisance as a rule, but with sufficient to keep a regularly-organised staff of men going steadily, the work would be done at a small expense and with considerable rapidity, so far as the number of castings produced in a given time is concerned. Instead of taking an hour to produce a mould in sand, four castings could be produced in the hour under favourable conditions, as the moulder would be eliminated after the metal mould was secured, men trained to handling the casting operations only being necessary.

At first, metal moulds work badly, as they have to get seasoned to the work, and a good many wasters would be turned out at first, but as the moulds get seasoned the wasters disappear and eventually become rather rare. There is, however, this to be said about wasters; they only cost the amount which is expended on melting and pouring, which, as a rule, is a comparatively small item, while it is not comparable with the loss involved where wasters are produced in ordinary sand moulding, which involves the loss of the moulder's time in every case.

The metal of which the moulds are made should be low in combined carbon and high in graphitic carbon, while the silicon content should not be too high. High silicon and combined carbon would probably cause the moulds to "grow" and become deformed, while cracking would certainly take place. The moulds are not chills, and should not be allowed to get much above 350 deg. F. while working, this not being difficult to manage owing to the castings being turned out as soon as set, or at least in the case of iron at about an orange-red. With other metals generally a lower temperature would be used both for pouring and removal from the mould, the shape of the castings, the metal used, and individual practice, being the determining factors for turning out the castings. To ensure the quick removal of heat the moulds must be thick, say from 2 in. upwards, according to the bulk of molten metal dealt with, each mould having to be treated according to its own particular purpose.

Hinged moulds should work freely, but without excessive play, and built-up moulds should have freely-fitting guide dowels to keep the parts in their proper positions. Wrought-iron handles will have to be cast in, as everything gets too hot to hold with the bare hands, and unless proper facilities are afforded in this direction trouble will certainly occur. Venting is only needed to carry off the confined air, as gases will not be generated, owing to the fact that clean metal must be used, and in most cases a slight amount of venting at the joints of the moulds will be all that is necessary.

In regard to the metal used in making the castings, it must be clean and fluid, and in the majority of cases it is desirable to use some flux of a deoxidant character to remove all traces of undesirable matter. In melting it will be found that the greatest fluidity occurs soon after melting point is reached, and that with accretions of temperature the molten metal becomes dull and sluggish, refusing to run up sharply, and in some cases only producing porous castings of a very unsatisfactory character, quite independently of the form of mould used. To some extent fluxes can be used to recover this overheated metal when it is again melted, while provided the right form of flux is used passable castings can be secured; but this should not be required, since proper melting makes their use unnecessary.

Where iron cores are used, these should be made of soft cast iron like the moulds, and for some time a coating of plumbago should be used with them, both for getting into good condition and to act as a lubricant. Their removal from the castings should take place at the interval between the solidification of the metal and the commencement of contraction, which, although brief, is yet long enough to enable the cores to be taken out. If the metal contracts before the cores are taken out, much difficulty will be experienced in removal. There is nothing to prevent sand cores being used provided they are dried thoroughly and coated with plumbago, but provision

must be made for venting where these are used. In removing iron cores, where possible, they should have a spiral or screwing motion imparted to them.

In dealing with metal moulds, the greatest trouble will be found with the operators, as at first they will find it difficult to get the exact time at which the mould should be opened and the casting thrown out, very many men treating these moulds as chills. For this reason it is at first desirable to deal with such things as wheel blanks or articles of a like character which do not surround any part of the mould, and from these work to other forms, as at first it is somewhat difficult to judge the proper time for opening the moulds.

Given good soft iron moulds, clean metal, and operators who take an interest in the work, making castings in permanent moulds should very largely reduce costs of producing articles where large numbers of similar parts can be utilised, as practically the moulder's work is eliminated after the moulds are once made, thousands of castings being obtainable from each mould when they are properly handled. Practically all metals and alloys can be dealt with, but there will necessarily be differences in their treatment. Above all, it must be remembered that the process is not a new one, but simply a development of a practice which has been in use for a considerable number of years in a slightly different form.

Vanadium in Brass.*

By R. J. Dunn, M.Sc., and O. F. Hudson, M.Sc., A.R.C.Sc.†

The actual effect of vanadium in alloys of copper and zinc does not appear to be well known, and it was thought that it would be useful, before attempting to investigate the general effect of vanadium on the properties of brass, to ascertain what, if any, were the changes brought about by small quantities of vanadium in the constitution and structure of those alloys of copper and zinc which contain between 50 and 60 per cent. of copper. The authors were also led to make such a preliminary study of the influence of vanadium by the observation of Carpenter that not more than 1 per cent. of vanadium was able to effect the resolution of the β constituent of the copper-zinc alloys into α and γ in the case of a cast alloy containing 51.25 per cent. of copper.

Attempts were made at first to prepare brasses containing vanadium by using commercial cupro-vanadium. Samples of cupro-vanadium were obtained from two sources—from an English and a German firm respectively—but on analysis the composition was found to contain large percentages of aluminium and iron, and it was impossible to prepare from these materials any alloys free from important quantities of impurities. In making the pure vanadium brasses, therefore, vanadic acid was used as the source of vanadium, the following method being adopted as a result of preliminary experiments: Copper was first melted, and then vanadic acid mixed with a weighed excess of powdered aluminium was slowly stirred in together with fluxes containing cryolite. Next the excess of aluminium was oxidised by the addition of an amount of copper oxide calculated from previous experience. After allowing the metal to cool somewhat, the slag was removed from the surface and the zinc stirred in. The brass so made was cast into a small cylindrical mould.

It was found that in all the alloys containing appreciable quantities of aluminium the temperature of the critical point is about 490 deg. C., and is independent of the vanadium present. In those brasses free from aluminium the temperature of the inversion rises very slightly with increasing vanadium, but it does not exceed 470 deg. C. with 1.5 per cent. of vanadium. Thus vanadium does not appear to affect the critical point to any marked extent, but the presence of small quantities of aluminium raises it distinctly.

The general conclusions drawn by the author are:—(1) The critical point occurring at about 460 deg. C. in brasses containing the β phase is only slightly affected by vanadium, 1 per cent. raising it not more than 10 deg. C.

(2) The usual structure of brasses containing between 50 and 60 per cent. of copper is not greatly modified by the presence of small quantities of vanadium, although alloys containing more than about 0.5 per cent. of vanadium were observed to contain some hard, bluish, slag-like inclusions.

(3) Vanadium to the extent of at least 1 per cent. appears to have no influence on the structural stability of the β constituent of the copper-zinc alloys, and if any structural resolution of β into α and γ follows the addition of cupro-vanadium to brass, the result probably is due rather to the relatively large amounts of aluminium usually present in commercial samples than to the small percentage of vanadium remaining in the finished brass.

TABLE I.—*Alloys made from Purified Cupro-Vanadium.*

Copper, per cent.	Vanadium, per cent.		Melting-point, Degrees C.	Critical point, Degrees C.
	Found.	Calculated.		
52.1	Trace	1.5	889	458*
52.6	,,	0.9	881	450*
52.5	,,	0.5	883	462†
52.6	,,	0.9	881	465†

* The cupro-vanadium contained 0.18 per cent. of aluminium.
† The cupro-vanadium contained 0.22 per cent. of aluminium.

TABLE II.—*Alloys made from Commercial Cupro-Vanadium which were Examined Thermally.*

Copper.	Vanadium.	Aluminium.	Iron.	Mean temperature of critical point.	Microstructure.
Per cent.	Per cent.	Per cent.	Per cent.	Degrees C.	
50.6	2.70	1.50	3.40	538	$\beta+\gamma$
55.0	0.62	1.01	1.19	496	β
48.0	3.06	1.45	2.41	527	$\beta+\gamma$
50.4	0.76	Trace	1.00	480	$\beta+\gamma$

TABLE III.—*Alloys ("Pure" Vanadium Brasses) made from Vanadic Acid.*

Copper.	Zinc.	Vanadium.	Aluminium.	Iron.	Mean temperature of critical point.	Microstructure.
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Deg. C.	
55.7	43.8	0.46	Trace	Trace	457	$\beta+\alpha$
50.1	48.9	0.94	,,	,,	465	$\beta+\gamma$
54.6	44.2	1.00	0.13	,,	472	β
53.9	45.4	0.53	0.15	,,	457	β
51.3	46.5	1.46	Trace	0.63	472	$\beta+\gamma$
57.9	41.7	0.31	Nil	Trace	456	$\beta+\alpha$
60.2	39.2	0.53	Trace	,,	462	$\beta+\alpha$
53.2	44.6	1.50	0.66	,,	496	$\beta+\gamma$
52.9	45.1	1.30	0.63	,,	490	β
52.4	45.8	1.00	0.67	,,	493	β
51.7	47.4	Nil	0.92	Nil	491	$\beta+\gamma$
52.5	47.5	,,	Nil	,,	455	β

* Abstract of Paper read before the Institute of Metals.
† Respectively Research Scholar and Lecturer in Metallurgy in the University of Birmingham.

The Annealing of Steel Castings.*

By A. T. Adam.

In a Paper read before this Association in 1911 Professor Campion laid stress on the time element in annealing steel castings, a factor which was too often entirely forgotten. With the object of gaining some definite information in regard to the effect of time on the heat treatment of steel castings, the writer made this the subject of the work carried out under Professor Campion's guidance last year. Unfortunately, the material supplied for this work was, to put it mildly, not all that could be desired, and the results obtained were far from conclusive. It is not the writer's intention to give the results in detail, but to review briefly the subject of the annealing of steel castings and to deal specially with the effect of time.

The purpose of annealing steel may be to increase its softness and ductility or to toughen it by securing a desirable combination of high strength and elastic limit with fair ductility. These changes of physical properties are brought about by corresponding changes in the structure of the material and by the removal of internal stresses set up during manufacture. In annealing forged or rolled material it is sufficient to heat it just through the critical range as indicated by the transition points A_2 and A_3, *and to maintain it at that temperature long enough to allow the structural changes to take place throughout the whole mass of the material.* The structure of steel castings, however, is so coarse and irregular that they require more drastic treatment, since it is necessary to produce by heat alone the changes that result from work plus heat in the case of forged or rolled material.

In determining the treatment necessary to obtain the best results in the final casting, there are so many points to be considered in conjunction with one another that it is quite impossible to lay down any definite rule with regard to any single point. Such a question, for instance, as "What is the best temperature to anneal steel castings?" cannot be answered without qualification.

If, then, we are to produce a good steel casting we must consider, among other things:—

(1) The purpose for which it is required.
(2) The mass of the casting.
(3) The shape of the casting.
(4) The composition of the material.

These points have to be considered along with the rate at which the material is to be heated in the annealing process; the length of time maintained at the annealing temperature, and the rate of cooling from the annealing temperature. It is obvious that the larger the mass and the more complicated the shape of the casting, the more carefully must these points be watched. There can be no doubt that the time element in the heat treatment of all kinds of material is far too often ignored. The reason for this, of course, is that time is money, and in some processes there is something to be said for the argument that it is better to raise the temperature a little too high in order to hasten the work and increase the output; but in the case of steel castings that is very dangerous, and it is probable that at least 50 per cent. of the so-called mysterious failures of material are due to a neglect of the time factor in annealing.

It is, perhaps, best to consider the time factor from two points of view:—(1) The time necessary to bring the whole of the casting to an even temperature, and (2) the time necessary to produce the changes of structure desired. With regard to the first point, it will be sufficient to mention that Professor Arnold, in conducting his research on the annealing of castings containing iron and carbon only, maintained his test bars at the annealing temperature for a period of 70 hours and allowed a further period of 100 hours for cooling. It is, however, with the second point, viz., the time necessary to produce the desired changes of structure, that the writer wishes to deal. No systematic study of the effect of time in producing changes of structure in annealing castings appears to have yet been made, and this, considering the importance of the subject, is somewhat strange, because it is quite possible that research on this point might solve the problem of how to turn out a casting which will compare in strength and reliability with forged steel in shapes so intricate that the cost of forging would be prohibitive.

In order to examine the effect of time, the writer decided to anneal several specimens of the same material for different periods, keeping the temperature and rates of heating and cooling constant; to apply one or two ordinary mechanical tests to these specimens, and to compare their structures as examined microscopically. Sample drillings from each set were analysed, and in each case cooling curves were taken, in order to find the most suitable annealing temperatures. These temperatures being fixed, the specimens were annealed as described in detail later. Microsections were cut from the ends of the bars after treatment, the inside surfaces being polished. The bars were then turned in order to carry out mechanical tests.

Three sets of specimens were available. Set No. I. consisted of 8 small pieces cut from a small ingot; and of a size suitable for micro examination. Set No. II. consisted of 13 bars of the same material, and of a size suitable for standard mechanical tests. Set No. III. consisted of 30 bars cut from one casting, annealed once at the ordinary temperature reached in works practice, and of a size suitable for standard mechanical tests.

Analysis and Treatment of Cast Steel No. 1.

C.	Si.	Mn.	S.	P.
0.19%	0.08%	0.58%	Normal.	

THERMAL ANALYSIS.

Ar_3.	Ar_2.	Ar_1.
815° C.	780° C.	665° C.

HEAT TREATMENT.

Annealing temperature, 830° C. Cooled in sand.

No. 1	As cast
	Time of annealing.
„ 2	5 mins.
„ 3	15 „
„ 4	30 „
„ 5	60 „
„ 6	120 „
„ 7	240 „
„ 8	360 „

Small pieces, suitable for microscopic examination only, were cut from the ingot and annealed in the electric resistance furnace used for taking the cooling curves, the temperature being controlled by the same thermocouple connected through a mirror galvanometer. By means of a resistance coil, the furnace was easily kept at a constant temperature. The annealing temperature chosen was 830 deg. C., a temperature just 15 deg. C. above the Ar_3 point. The specimens were all placed in the furnace, and the

* Paper read before the British Foundrymen's Association, Glasgow February 28th, 1914, Professor Campion in the chair.

hot junction of the thermocouple was placed in their midst. The furnace took about ¾ of an hour to reach the desired temperature. Each specimen was withdrawn as soon as its time of annealing was up, and cooled in sand which had been warmed.

The effect of annealing this casting at 830 deg. C. was very distinctly revealed in the change of structure, but the annealing period of those very small specimens appears to be of little importance, probably because a period of 15 minutes is sufficient to bring about changes of structure which might take several hours in the case of a very large casting. The chief point to be noticed is that, although the annealing temperature was only 830 deg. C., the structure in every case, except, perhaps, in the specimen annealed for five minutes, was quite homogeneous, and the typical coarse and irregular structure of cast material was removed.

Analysis and Heat Treatment of Cast Steel No. II.

C.	Si.	Mn.	S.	P.
0.39%	0.25%	0.53%	0.033%	0.041%

Thermal Analysis.

Ar_3.	Ar_2.	Ar_1.	Ac_2. Ac_3	Ac_1.
730		680	780	754

Heat Treatment.

Annealing temperature, 820° C.	Cooled in furnace.
No. 1	As cast.
	Time of annealing.
,, 2	1 hour.
,, 3	2 hours.
,, 4	4 ,,
,, 5	8 ,,
,, 6	20 ,,
,, 7	30 ,,

These specimens were annealed in a gas reverberatory furnace. The heatings were controlled by a thermocouple, carefully protected from the flame of the furnace, and connected through a millivoltmeter. Great care was taken to ensure that the temperature of the hot junction was identical with that of the specimens, and the furnace was so carefully watched that we are confident the annealing temperature was constant within ten degrees Centigrade for all heatings. The time required to heat the material to the desired temperature and that required to cool it was the same in all cases. The specimens were enclosed in wrought-iron boxes, sealed up to prevent decarburisation.

Tests Carried Out After Treatment.

Mechanical Tests.—The bars were turned down to a cross-sectional area of ½ sq. in., with a length of 3 in. In carrying out these tests we found that at least half of the material was worthless, and that the other half was of doubtful quality. This was naturally a great disappointment, as it deprived us of much important evidence, and rendered the remaining evidence incomplete. It is fully realised, therefore, that the results are far from conclusive, and were it not for the hope that they may be sufficient to open a discussion, they would not be considered in this Paper.

When we came to consider the mechanical tests we found that only in the case of the material annealed for a period of two hours did we get any marked improvement. Table I. compares the cast material with No. 3 bar. These results, we may say, are the means of duplicates, and although they are no doubt due in part to the fact that the bars heated for two hours happened to be the pick of the bunch, they show that the ductility of the casting has been increased by annealing for this period at a temperature far below that usually employed. Moreover, the effect of time in annealing at this temperature was distinctly noticeable in regard to two other points:—(1) The grain of the fracture was finer the longer the time of annealing; (2) while the original material and that heated for short periods only gave no definite yield point, the material heated for periods from eight hours to thirty hours gave a very definite yield point (in each case about 18 tons/sq. in.).

Table I.—*Showing Results of Mechanical Tests on Cast Steel No. 2.*

Treatment.	Yield point in tons per square inch.	Max. stress in tons per square inch.	Per cent. contraction area.	Per cent. extension on 3 in. length.	Per cent. extension on 2 in. length.	Per cent. extension on 1 in. length.
As cast ..	—	31	8.05	7.2	7.5	7.5
2 hours ..	—	28.8	20.4	18	20	25
8 hours ..	17.6	33	9.5	8.8	10	12
30 hours ..	17.7	33.8	11.7	10.7	11	13

Microscopic Examination.—Again the effect of annealing at the comparatively low temperature of 820 deg. C. was very distinct, especially in the cases of the bars heated for 2 hours, 20 hours and 30 hours. In three cases, however, the material seemed to be insufficiently annealed, viz., in the material heated for 1, 4 and 8 hours respectively.

Analysis and Heat Treatment of Cast Steel No. 3.

C.	Si.	Mn.	S.	P.
0.25%	0.27%	0.73%	0.018%	0.028%

Thermal Analysis.

Ar_3.	Ar_2.	Ar_1.	Ac_3.	Ac_2.	Ac_1.
809° C.	790° C.	665° C.	850° C.	825° C.	755° C.

Heat Treatment (Set A).

Annealing temperature, 820° C.	Cooled in furnace.
No. 1	As received.
	Time of annealing.
,, 2	1 hour.
,, 3	2 hours.
,, 4	4 ,,
,, 5	8 ,,
,, 6	10 ,,
,, 7	20 ,,
,, 8	30 ,,
,, 9	1½ ,,

Set B.

Annealing temperature, 860° C.	Cooled in furnace.
No.	Time.
2	30 mins.
3	1 hour.
4	2 hours.
5	4 ,,
6	8 ,,
7	16 ,,

This material had already been annealed at a temperature of about 900 deg. C. in the works, and we used it to examine the effects of a second annealing at a lower temperature and for different periods.

The heatings of these bars were carried out in the same furnace as set No. 2. All the specimens were cooled in the furnace as before.

Tests Carried Out After Treatment.

Microscopic Tests.—An examination of these microsections showed that all the material annealed for a second time at the lower temperature of 820 deg. C. had a fine, regular structure, consisting of small pearlite grains, evenly distributed throughout the ferrite, while the material annealed at 860 deg. C. retained the original structure of large pearlite grains. This evidence seems to indicate clearly enough that the second annealing at the lower temperature has improved the material. As regards the effect of time in this case it is not so noticeable; a period of two hours seems to be sufficient.

Mechanical Tests.—Again, most of the material proved unsound, and we were deprived of many of the duplicate results so necessary in making comparisons. On the whole they verified the conclusions drawn from the microscopic tests.

Conclusions.

While it would be absurd to dogmatise from such scanty evidence as is here produced regarding the

best method of annealing steel castings, there can be no harm in summarising the evidence, such as it is, and treating any conclusions drawn from it as theories requiring proof by further research on a much larger scale, with reliable material.

(1) In spite of the apparently negative results of the mechanical tests, there is distinct evidence that annealing for a prolonged period permits of the temperature being lowered, so that not only is the structure of the casting thereby rendered more homogeneous, but the risk of overheating is considerably reduced.

(2) Castings which have been annealed at a high temperature will be given a finer and more homogeneous structure if they are re-annealed at a temperature slightly above the lower recalescence point A_2, and maintained at that temperature for a period equivalent to two hours in the case of a small test bar—large castings will, of course, require a much longer period. It is at least certain that annealing for a prolonged period cannot harm the material, provided it is protected from oxidation and the temperature is not too high.

Discussion.

The CHAIRMAN (Professor Campion) said that the experiments which Mr. Adam had carried out had proved, through unforeseen circumstances, not so successful as had been anticipated, and the difficulty of obtaining material was in a large measure responsible. It had been hoped that some valuable results would have been obtained from the experiments, but in this they had been disappointed. The work, however, was still going on. Fresh castings were being prepared, and steps were being taken to see that these were absolutely sound. They were being specially prepared for the work and would be as sound as it was possible to obtain them before any time was wasted on making experiments. It might, therefore, be hoped that the work, when finished, would produce results which would be of great interest to steel founders and to users of steel in general.

A VISITOR remarked that it had been his own good fortune some little time ago to have charge of a new electrical furnace, and the object of this furnace, and the object of the makers of the castings who secured this furnace, was to do away altogether with the annealing of castings. In this respect they considered themselves eminently successful. The furnace in question came from Italy. The castings were intended for use particularly in connection with motor-car work, and splendid results were got, the castings requiring no annealing whatever. They possessed, he claimed, all the properties which annealed castings from any other ordinary furnace possessed.

IN an interesting paper read before the members of the Society of Engineers on the advantages of adopting Esperanto as a universal language for engineers, Mr. T. J. Gueritte advances four main reasons for the adoption by scientific and technical men of a universal language. These are:—(1) Modern science is to a considerable degree, specialised and international. Engineers, of whatever nationality, are obliged to study works by authors of other nations. (2) In the actual carrying out of engineering works or the pursuit of research abroad a man comes in contact with people of diverse nationalities, and it is a difficult and interminable task to master a number of different languages. (3) The work of international congresses would be greatly facilitated and their expense reduced. (4) The present high prices of technical books would be reduced, because, if written in an international language they would have a much wider circulation, and translations would not be necessary.

Institute of Metals.

The annual general meeting of the Institute of Metals was held at the Institution of Mechanical Engineers on Tuesday and Wednesday, March 17 and 18, the retiring President, Professor A. K. Huntington, presiding at the outset.

In their annual report the Council state that the year 1913 witnessed considerable and important advances in the Institute's activities, notably in the direction of the first foreign meeting and the presentation of the Second Report to the Corrosion Committee. The number of members on the roll at December 31, 1913, was as follows:—Honorary members, 3; ordinary members, 604; student members, 19; total, 626.

Corrosion Committee.

The report refers to the Second Report received from the Committee's Investigator, and read at the Ghent meeting. Since its publication, experimental work has been actively resumed and a number of improvements have been carried out in the apparatus employed. A copper-aluminium alloy and phosphor-bronze have been added to the list of alloys previously studied, but work on Muntz metal has been discontinued. An elaborate study is being made of the mode of action of estuarine waters, which practical experience has shown to be particularly harmful. Work is being continued on the subject of electro-chemical protection. A salaried assistant to the Investigator has recently been appointed, in order that the experimental work may be pushed on more rapidly, Mr. W. E. Gibbs, M.Sc., having been selected for the position.

Treasurer's Report.

The Honorary Treasurer (Professor Thomas Turner, M.Sc.) reports a satisfactory result on the financial side of the work of the Institute. The balance at the beginning of the financial year was £563 10s. 11d.; this was increased during the year to £699 6s. 3d., which latter sum included £50 put aside to meet a future liability in connection with Dr. Beilby's prize. The actual addition to the reserves of the Institute was therefore £85 15s. 4d., which though less than in the previous year is still satisfactory.

New Officers.

The result of the ballot for officers and members of the Council for 1914 was as follows:—Engineer Vice-Admiral Sir H. J. Oram, President; Mr. G. A. Boeddicker (Birmingham), Professor H. C. H. Carpenter (London), Mr. R. Kaye Gray (London), Mr. Summers Hunter (Wallsend-on-Tyne), Mr. J. T. Milton (Lloyd's Register), Professor T. Turner (Birmingham), Vice-Presidents; Mr. L. Archbutt (Derby), Professor A. Barr (Glasgow), Mr. T. A. Bayliss (King's Norton), Dr. G. T. Beilby (Glasgow), Mr. A. Cleghorn (Glasgow), Mr. George Hughes (Horwich), Dr. R. S. Hutton (Sheffield), Mr. W. Murray Morrison (London), the Hon. Sir C. A. Parsons (Newcastle), Mr. Arnold Philip (Portsmouth), Dr. W. Rosenhain (Teddington), Mr. A. E. Seaton (London), Sir W. E. Smith (London), Mr. L. Sumner (Manchester), and Mr. C. H. Wilson (Sheffield), Members of Council; Mr. G. G. Poppleton (Birmingham), Honorary Auditor; and Mr. G. Shaw Scott, Secretary.

PROFESSOR HUNTINGTON, in responding to a vote of thanks to the Council, referred to the rapid progress which the Institute had made.

A vote of thanks was warmly accorded to the retiring President.

Abstracts of some of the Papers presented at the meeting are given on other pages of this issue.

Foundry Sands and their Treatment: Tests for Refractory Values.

By Algernon Lewin Curtis, M.E.

Material Tested :—**WORCESTERSHIRE SAND (Stourport).** *Weight of Sample* :—100 Grammes. *Colour and Description* :—Light Brick Red. *Consistency* :—Under Medium Strength. *Surface Factor or Size* :—(Grammes per cent.)—Retained on 50 sieve, 0.010; Retained on 100 sieve, 55.950; Sieved through a 100 sieve, 44.040. *Water Required for Maximum Cohesiveness when Dried One Hour at 100 Deg. Cent.* :—4 Per Cent. *Venting Capacity of 1 Cu. In. when Mixed 400 Times with 4 Per Cent. Water and Rammed at a Pressure of 25 lbs. per Square Inch* :—About 1¼ lbs. Air Pressure. *Plate* :—Wellington and Ward, "Anti-Screen." *Objective* :—1 in. Watson.

No. 1.—Normal Temperature. Mag. × 50 Diams.

Remarks.—Quantities of Live Mica are Visible in Material in its Natural State.

No. 2.—Exposure to 1,200° C. Mag. × 50 Diams.

Remarks.—Specimen Expanded in the Form of a Camber $\frac{3}{64}$ in. in a Length of 2½ in.

No. 3.—Exposure to 1,300° C. Mag. × 50 Diams.

Remarks.—Same Expansion as in Test Piece No. 2.

No. 4.—Exposure to 1,400° C. Mag. × 50 Diams.

Remarks.—Specimen Expanded in the Form of a Camber $\frac{1}{16}$ in. in a Length of 2½ in.

No. 5.—Exposure to 1,500° C. Mag. × 50 Diams.

Remarks.—Slight Exfoliation. Specimen Broken by Heat.

No. 6.—Exposure to 1,600° C. Mag. × 50 Diams.

Remarks. — More Exfoliation. Specimen Broken by Heat, nearly Completely Fused to a Whitish-Greenish Glass.

No. 7.—Exposure to 1,700° C. Mag. × 50 Diams.

Remarks.—Medium Exfoliation. Specimen Very Weak, Broken by Heat and Fused to a Whitish-Green Glass.

No. 8.—Exposure to 1,800° C. Mag. × 50 Diams.

Remarks.—Medium Exfoliation. Specimen much Weaker, Broken by Heat and Whole Face Completely Fused to a Whitish-Green Glass.

Material Tested :—**DEVONSHIRE SAND.** *Weight of Sample* :—100 Grammes. *Colour and Description* :—Reddish Yellow to Brown. *Consistency* :—Medium Coarse, Strong. *Surface Factor or Size* :—(Grammes per cent.)—Retained on 50 sieve, 6.550; Retained on 100 Sieve, 73.800; Through a 100 Sieve, 19.650. *Water Required for Maximum Cohesiveness when Dried One Hour at 100 Deg. Cent.* :—5 C.C. per cent. *Venting Capacity of 1 Cu. In. when Mixed 400 Times with 5 Per Cent. Water and Rammed at a Pressure of 25 lbs. per Square Inch* :—About 7 lbs. Air Pressure. *Plate* :—Wellington and Ward, "Anti-Screen." *Objective* :—1 in. Watson.

No. 1.—Normal Temperature. Mag. × 50 Diams.

Remarks.—Works Well in Moulds; Medium Strong Sand, evenly Constituted.

No. 2.—Exposure to 1,200° C. Mag. × 50 Diams.

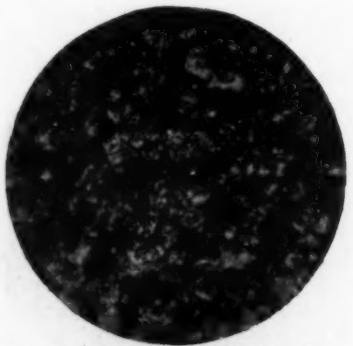
Remarks.—Test Piece Expanded $\frac{1}{16}$ in. in the Form of a Camber in a Length of 2½in. Not Damaged by Heat. Strong.

No. 3.—Exposure to 1,300°C. Mag. × 50 Diams.

Remarks.—Test Piece Strong, Expanded like No. 2. Little Affected by Heat.

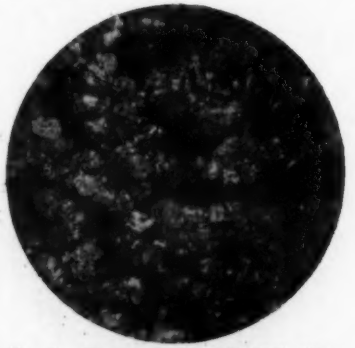
No. 4.—Exposure to 1,400° C. Mag. × 50 Diams.

Remarks.—Test Piece Strong and Unbroken. Expansion same as No. 2. Little Affected by Heat.



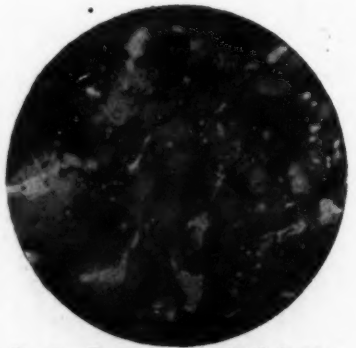
No. 5.—Exposure to 1,500° C. Mag. × 50 Diams.

Remarks.—Test Piece Strong and Unbroken. Expansion same as No. 2. Little Affected by Heat.



No. 6.—Exposure to 1,600° C. Mag. × 50 Diams.

Remarks.—Test Piece Expanded $\frac{1}{32}$ in. in the Form of a Camber in a Length of 2½ in. Strong and Unbroken. Very Slight Fusion Taking Place.



No. 7.—Exposure to 1,700° C. Mag. × 50 Diams.

Remarks.—Test Piece Expanded $\frac{1}{32}$ in. in the Form of a Camber in a Length of 2½ in. Very Slight Exfoliation. Test Piece Medium Strong, and Partly Fused to a Yellow-Grey Glass.

No. 8.—Exposure to 1,800° C. Mag. × 50 Diams.

Remarks.—Test Piece Expanded $\frac{1}{16}$ in. in the Form of a Camber in a Length of 2½ in. Slight Exfoliation. Specimen Fairly Strong and Nearly Completely Fused to a Yellow-Grey-Green Glass.

Bronze.

By John Dewrance.

The dictionary meaning of the word "bronze" is a compound or alloy of from 2 to 20 parts of copper to 1 of tin to which other metallic substances are sometimes added, especially zinc. In times past, the gradually increasing additions of zinc and lead discredited the name of bronze. In the manufacture of guns, it was found that the best results were obtained by an alloy of 9 parts of copper and 1 part of tin. This became the standard material for the manufacture of guns for many years.

To distinguish this alloy from the inferior mixtures that had previously been supplied under the name of bronze, the description gun metal was introduced. As time went on the new name gun metal was no more respected than the old one of bronze, and at the present time any alloy that does not come under the description of pot metal or brass is called gun metal. As guns are now universally made of steel, it seems desirable to return to the dictionary description and to call all alloys, mainly composed of copper and tin, "bronze."

To the previously mentioned alloy of 90 per cent. copper and 10 per cent. tin, it is very largely the practice to add 2 per cent. of zinc, making 88 per cent. copper, 10 per cent. tin, and 2 per cent. zinc. When tested at atmospheric temperature this alloy gives excellent results. As a great deal of bronze is used at the temperature of high-pressure steam it becomes important to investigate its behaviour at temperatures that correspond. The tests, the results of which are given in Figs. 1 to 4, were conducted for the author by Mr. R. H. Harry Stanger. The heating apparatus was an air-tight tube boiler heated by gas from a ring-burner. The specimen was held in screwed jaws in the centre, both end jaws being insulated, and the boiler was also coated with asbestos. The testing-machine being a 50-ton vertical Buckton, the weight of the apparatus was carried on the bottom headstock; the top end of the specimen was held in a plunger which entered the top of the heating apparatus through a broad guide with a sliding fit. Both ends of the apparatus were held in the headstocks by means of spherical holders, thus allowing the whole to find its true vertical axis.

As the specimen was entirely enclosed during the test, some outside means had to be adopted for ascertaining the yield point, if any; the two ends of the heating apparatus were connected to a Wickstead hydrographic recorder, taking the base line with the beam floating immediately before applying the load after the specimen had attained the necessary temperature. The percentages of elongation were given by the Wickstead recorder, and are stated throughout as the percentage on 2 in.

The copper emp'oyed in these tests was that which is known on the market as "Best Selected," which has an average analysis as follows:—Copper, 99.55 per cent.; nickel, 0.01 per cent.; arsenic, 0.026 per cent.; lead, 0.08 per cent.; bismuth, 0.004 per cent. The tin and zinc were of the best commercial quality.

In the first tests made 88 parts of copper were melted in a new crucible, 2 of zinc were added as soon as the copper was melted and allowed a short time to flux the metal, 10 of tin were then added, the whole mass stirred, and the test-pieces poured at as near the same heat as could be judged by a careful moulder.

The black line on Fig. 1 shows that at atmospheric temperature the 88 copper, 10 tin, and 2 zinc alloy has a maximum stress of 16.35 tons per square inch, and the black line on Fig. 2 shows an elongation of 11 per cent. on 2 in. At 400 deg. F. it has a maximum stress of 9.5 tons and an elongation of only 1 per cent. At 700 deg. it has a maximum stress of 7 tons and an elongation of 0.25 per cent.

The first series of tests undertaken was that between 400 deg. and 700 deg. F., and the results were so unexpected that it was thought advisable to re-test some of the broken samples in the cold state, to ascertain if the fault was in the casting of the test-pieces. For this purpose samples which had failed at 400 deg. F. and 500 deg. F. were turned down and suitably mounted, and when re-tested at atmospheric temperature gave a breaking stress near 18 tons per square inch. Further samples in this same mixture were then prepared and tested at temperatures between atmospheric and 400 deg. F., and

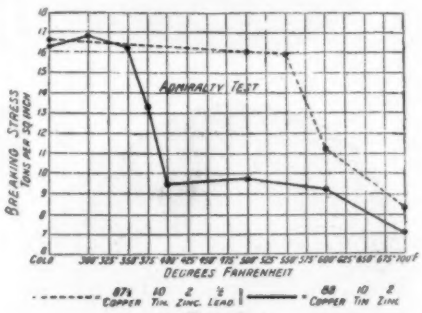

BREAKING STRESS TONS PER SQ INCH
ADMIRALTY TEST
DEGREES FAHRENHEIT
COLD
87½ COPPER 10 TIN 2 ZINC ½ LEAD
88 COPPER 10 TIN 2 ZINC

FIG. 1.

the results, embodied on the diagram, Fig. 1, show very clearly that the metal begins to lose its strength above 350 deg. F.

In the next tests made 87½ parts of copper were melted in a new crucible, 2 of zinc were added as soon as the copper was melted and allowed a short time to flux the metal; 10 of tin and ½ of lead were then added together, and the whole mass stirred. It will be observed that the only difference between this and the previous experiments is the addition of ½ per cent. of lead at the expense of the copper. The dotted line in Fig. 1 shows that at the atmospheric temperature the maximum stress is 16.5 tons per square inch, and the dotted line on Fig. 2 the elongation 8 per cent. At 550 deg. F. it has a maximum stress of 15.8 tons and an elongation of 18 per cent. At 700 deg. it has a maximum stress of 8.25 tons and an elongation of 2 per cent. The breaking stress of 11.25 tons per square inch at 600 deg. F. is an average. No actual sample broke at this stress. It was found that some samples tested at this temperature gave results in the region of 16 tons per square inch, and other 7 tons per square inch. From this it may be concluded that 600 deg. is the critical temperature of this alloy.

* Abstract of Paper read before the Institute of Metals

If it is accepted that ½ per cent. of lead raises the maximum stress at 500 deg. F. from 9.75 tons to 16.5 tons, that proportion of lead becomes an essential ingredient in bronze, that is, subjected to temperatures above 350 deg. F. It also becomes necessary to inquire whether any further advantage can be gained by adding a larger proportion of lead. Figs. 3 and 4 show that this is not the case; but it is surprising that with so large a proportion as 16 per cent. of lead the maximum stress at 500 deg. F. is 12½ tons, as against 9.5 tons without any lead.

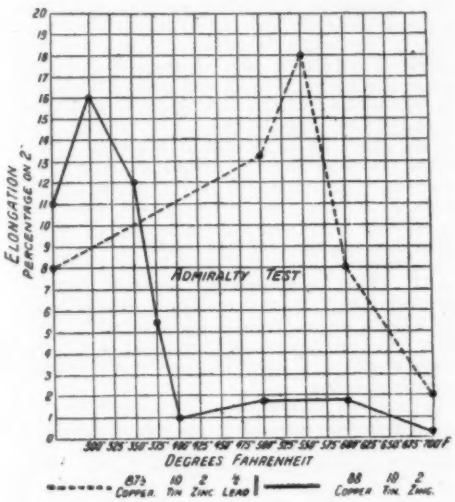


FIG. 2.

In making these experiments the lead was added at the expense of the copper. So the last result would be 72 per cent. copper, 10 per cent. tin, 2 per cent. zinc, 16 per cent. lead.

In making the foregoing experiments the question arose as to whether any of the results were due to the absorption of oxygen from the atmosphere by the alloy when in a molten condition. It is difficult to determine the content of oxygen in bronze, so the

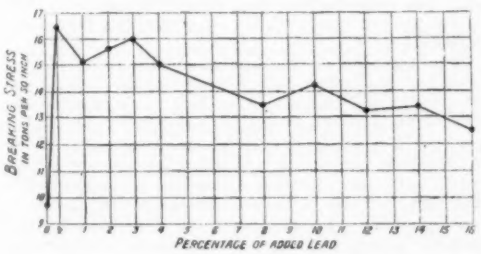


FIG. 3.—TESTED AT 500 DEG. F.

following experiments were conducted with best selected copper:—

Experiment No. 1.—A new 100-lb. plumbago crucible was taken. As soon as the copper was sufficiently hot an ingot was cast, and the rest of the metal was returned to the fire for an hour, when a second ingot was cast, and the same thing repeated for the third ingot. There were thus three ingots cast from the same crucible at intervals of one hour. On analysis the oxygen contents of the three were as follows:—

	Oxygen.	Cuprous Oxide.
	Per cent.	Per cent.
No. 1	0.032	0.285
No. 2	0.272	2.499
No. 3	0.404	3.605

Experiment No. 2.—Two new plumbago crucibles containing 100 lbs. of B.S. copper were taken, and ¼ lb. of 10 per cent. phosphor copper was added to one, and 0.6 oz. aluminium to the other, as deoxidisers. The copper was covered with glass, so that when molten no air could come in contact with it; and three ingots were cast at intervals of one hour, as in the former experiment, the glass being left on during the casting.

		Oxygen.			Oxygen.
		Per cent.			Per cent.
Aluminium as deoxidizer	No. 1	0.084	Phosphorus as deoxidizer	No. 1	0.036
	No. 2	0.080		No. 2	0.036
	No. 3	0.092		No. 3	0.036

Both sets of results show that if the metal is kept from contact with the air when molten no oxygen is picked up; and if this precaution is not taken each melting will result in an increase in the content of

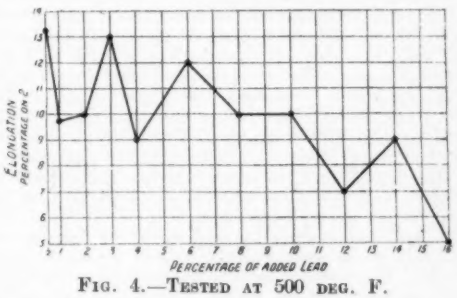


FIG. 4.—TESTED AT 500 DEG. F.

oxygen, and this conclusion was accepted and acted upon when making the following experiments. The products were not analysed for oxygen on account of the difficulty of such analysis.

Experiment No. 3.—One new plumbago crucible containing 100 lbs. of 87½ per cent. copper, 10 per cent. tin, 2 per cent. zinc, and ½ per cent. lead was covered with glass to exclude the air and melted; another exactly similar charge was allowed ample opportunity to pick up oxygen by being repeatedly skimmed and left standing in the air after being taken from the fire. Test-pieces, and a heavy flange casting with a light and thin nipple on each side, were cast from each crucible. The flange castings were broken and examined very carefully, and both appeared as sound as it is possible to get a casting. The test-pieces gave the following results when tested cold and under heat:—

	Temperature.	Maximum load in tons per square inch.	Extension on 2 inches. per cent.
First charge covered with glass to exclude oxygen ..	Cold	15.17	9.0
	At 500° F.	13.73	10.5
Second charge uncovered to absorb oxygen	Cold	16.55	12.5
	At 500°F	15.15	14.0

Experiment No. 4.—To complete the above results a similar flange and test-pieces were cast in "twice-run" metal. The flange casting again proved sound, and the test-pieces gave the following results:—

	Temperature.	Maximum load in tons per square inch.	Extension on 2 inches, per cent.
Metal twice run without any precaution to prevent absorption of oxygen ..	Cold	15.19	8
	At 500° F.	16.15	14

The foregoing experiments point to the conclusion that in an alloy of 87½ per cent. copper, 10 per cent. tin, 2 per cent. zinc, and ½ per cent. lead, no benefit results from the deoxidation of the metal, or in taking special precautions to prevent the metal absorbing oxygen.

There is another feature of considerable interest in these alloys. When the alloy that is free from lead is turned in the lathe the turnings have a considerable curl upon them. The addition of ½ per cent. of lead materially reduces the length of the turnings. It would naturally be supposed that this feature is due to the fact that without the lead the alloy has an elongation of 11 per cent. on 2 in., and with the addition of the lead the elongation is reduced to 8 per cent., and that the turnings break off more readily for this reason.

The same test-pieces from which the turnings were made when cold were then heated and turned at 550 deg. F. The alloy without the lead still presented the same curly appearance, and the turnings from the alloy containing the ½ per cent. of lead were very little longer than the turnings produced at the cold. The elongation of the alloy containing ½ per cent. of lead, as will be seen by the chart, is at 550 deg. F., 18 per cent. on 2 in.; whereas the elongation of the alloy without the lead falls at this temperature below 2 per cent.

As lead has such a marked effect on bronze, enabling it to be used without loss of strength up to 550 deg. F., it seems reasonable to expect that some other metal might be added that would enable the bronze to withstand even higher temperatures. With this object in view 87.25 copper was melted in a new crucible, and 0.25 of silver was added when the copper was melted, and the whole mass stirred. Ten per cent. of tin and 2 per cent. of zinc, and ½ per cent. of lead were then added and again stirred. Two test-pieces were prepared and tested at 700 deg. F. One test-piece gave a maximum load of 8.11 tons, the other 8.75 tons. The extension in neither case exceeded 0.5 per cent. on 2 in. The maximum load is practically the same as without the silver, and the extension not so good.

Nickel is not very promising, as in small proportions it seems invariably to liberate some occluded gas on cooling, and produces very porous castings.

Aluminium is objectionable, because in even small proportions it seems to add materially to the amount of the contraction of the casting on cooling.

Iron is strongly objected to in fine bronzes, as it combines with the tin and separates out into hard masses in the casting.

THE output of pig-iron during the past year at the Bengal Iron & Steel Company's works has been readily absorbed, and to meet the increasing demand for the company's brands of iron a third furnace has recently been put in blast. The new pattern and smiths' shops are in use, and the new machine shop is nearly complete. The new general foundry is in course of erection.

Carbon in Cast Iron.

Before a meeting of the Halifax Branch of the British Foundrymen's Association, held at Leeds on February 28, Mr. F. J. Cook lectured on "Some Aspects of Carbon in Iron." The substance of the lecture has already appeared in our columns under the title of "Cast Iron: Its Nature and Properties" (see January issue). Mr. J. Hartley Wicksteed, M.Inst.M.E., M.Inst.C.E., was in the chair.

The CHAIRMAN, in introducing Mr. Cook, remarked that cast iron was only about 400 years old, whilst wrought iron was 4,000 years of age. Cast iron had played an important part in some of our great engineering schemes, and it was quite up to its work. The Sunderland bridge was made of cast iron, and had one of the largest spans in the country. Also there was the High Level Bridge at Newcastle. The Tay Bridge was also made of cast iron, but it was not a success. He mentioned this to point out the importance of being certain that the material used was capable of standing the stresses placed upon it.

MR. COOK, in the course of his remarks, said he had been asked to make his remarks as elementary as possible. Cast iron consisted of from 89 to 94 per cent. iron, and of the remaining constituents the total carbon varied from 3 per cent. to 4 per cent., whilst the proportion of combined and graphitic carbon would vary according to the amount of other elements present.

The lecturer showed on a blackboard the analysis of a commercial cast iron:—Total carbon, 3.2 per cent.; combined carbon, 1.06 per cent.; graphitic carbon, 2.15 per cent.; silicon, 1.63 per cent.; sulphur, 0.116 per cent.; phosphorus, 1.369 per cent.; manganese, 0.320 per cent. The analysis would vary according to the various districts where the iron was obtained; total carbon varying from 2 to 4½ per cent.

A knowledge of the effect of these so-called impurities enabled one, by judicious blending and eliminating, to get vastly different physical properties in iron. The changes which the different constituent elements made in iron were due to the fact that they did not form merely mechanical mixtures, but went into combination with the iron and formed chemical compounds. The compounds of carbon and iron were very different from either carbon or iron, and the combination had the effect of considerably reducing the temperature at which the iron became molten.

The lecturer at this point exhibited micrographs showing the effect of different combinations upon the structure of the iron, and then proceeded to deal with carbide of iron or combined iron and carbon. There were, he said, other compounds such as manganese and sulphur forming manganese sulphide, which could be observed under the microscope. There was also a stage between the combined carbon and the graphite in castings that was known as the pearlite stage, this name being given to it owing to the mother-of-pearl appearance. In all irons of high strength pearlite was associated. He here exhibited slides showing the phosphide eutectic, and then dealt with the effect of other elements on iron, such as silicon, sulphur and manganese. Silicon itself had a tendency to make iron harder, but up to a certain point it acted as a softener because it extended the time of cooling, sulphur and manganese having quite the opposite effect, reducing the fluidity of the iron. Anyone who had to deal with iron in a foundry would know what an important effect the rate of cooling had on the quality of the iron obtained. The explanation was that the longer the

iron remained fluid the more carbon separated out in the form of graphite, whilst quick cooling retained the carbon in the combined form. Nearly everything depended on the state of the carbon, the physical properties being determined by the condition and quantity of the carbon present.

The CHAIRMAN, in opening the discussion, said they had been shown by the lecturer how to raise the strength of iron through scientific examination and treatment to double its original strength. If this became universal the commercial value to engineering would be enormous.

MR. MOORHOUSE asked in what manner the wedge-shaped bar of iron was cast which gave such remarkable results, whether it was cast with the point up or down?

MR. COOK, replying, said the bar was cast in open sand, pointed downward; the heavier part being at the top, gave the point what benefit there was of annealing. Had the point been cast uphill it would have been harder still.

MR. MARTIN said his own tests of chilled bars had worked out the very opposite to the lecturer's; their breaking point was lower than that of unchilled bars. The tests with the wedge-shaped piece bore out the claim that the thicker the iron the softer it was likely to be. If white iron was of no use in the foundry, why should Mr. Cook recommend it? Taking the lecture as a whole, he was disappointed; he was not a scientific man, and had come hoping to get some practical information.

MR. COOK replied that he was sorry his information had not helped Mr. Martin, but he would tell him the observations which had been put before them had not been obtained in a laboratory, but by a practical foundryman to help him in practical everyday work. His experience in chilling had taught him that bad results depended upon the metal started with. The first series gained 30 per cent., the largest benefit being 85 per cent. increase, the difference being in the thickness of the chill. This was how they had to counteract bad effects caused through unequal sections in one casting. If those who were responsible for the designing of castings would take notice of the wedge-shaped test results, they would realise that thick and thin parts in a casting produced a similar difference of hardness and strength. Wherever there was a bit of flush attached to a casting it was white iron. In respect to the last question, the lecturer said he had not recommended the use of white iron in the foundry.

MR. CARRICK, referring to the research work done by the lecturer, said the benefits derived by foundrymen had been enormous; personally, he had much for which to thank Mr. Cook. The importance of the rate of cooling must have struck the engineers present; it was their business to look into it.

MR. E. N. SMITH said he had been interested from a metallurgical point of view, and he would like to know the reason why of the two slides showing spots of manganese sulphide, the spots on one slide should be light and the other dark in colour. Also he would like to know if the lecturer had got so far with his research work as to be able to state definitely how the network structure which indicated strength could be produced?

MR. COOK, replying, said the research work had not yet been carried far enough to give a definite answer, but he was producing it regularly by regulating his blast pressure, taking analysis of metal, and watching the rate of cooling. With regard to the colour of the slides showing manganese-sulphide spots, in the one case illumination had been more concentrated. In answer to a question by Mr. Carrick as to whether both series of tests quoted had been taken on hot-blast iron or otherwise, he said that one was refined iron and the other hot-blast. Strong irons had to be produced in the blast furnace at a lower heat than weaker irons. This accounted for the inferiority of much of the American iron. The rate of production was greater than in England, but the iron was not nearly so good.

MR. S. G. SMITH asked what the lecturer meant by "a refined iron." Did a hot-blast or a cold-blast make the difference? He thought if the lecturer had given the evening to talking of carbon in its different forms it would have been sufficient for one night. The great difference in white iron and grey was that white iron had no pasty condition, and grey had. The most important stage was just when the iron was in that pasty condition. It was then that graphite separated out. It would be seen that white iron having no pasty condition retained the carbon in the combined form. He had taken some tests from irons containing low and high percentages of silicon with $\frac{3}{8}$ in. and $\frac{3}{4}$ in. chills respectively, and the best results in both cases were about the same. The remarks on network structure constituted the most important point in the whole lecture. If the theory of this could only be developed, it would be a great boon; he had seen with the naked eye this structure forming in iron just going from No. 4 to mottled.

MR. COOK said that so-called refined iron was made in blast furnaces. His own tests agreed with Mr. Smith's in connection with low- and high-silicon iron. The action of silicon was to extend the period of cooling. He had no difficulty in producing a net-like structure every day, but he could not tell anyone else just how to do it under their own conditions. They had to know their iron, while blast pressure and rate of cooling were the other two essentials.

MR. BARNETT, in moving a vote of thanks to the lecturer, said that the lecture had almost been too full for one evening. Foundry work presented very many problems, perhaps more than any other branch of engineering. It was not because there was any the less need for examination of the problems which presented themselves, but that they were very difficult to solve. The solution of the problems would not be found by experience or by guesswork.

MR. FAIRLEY, in seconding the motion, which was heartily carried, said there seemed to be something akin to memory in cast iron. Bad treatment in the making repaid them by bad results and accidents.

CATALOGUES RECEIVED.

JOHN HUDSON & COMPANY'S SUCCESSORS, 4, Victoria Warehouses, Mansell Street, London, E.—A booklet issued by this company deals with "Manganesite" packing for high-pressure steam joints.

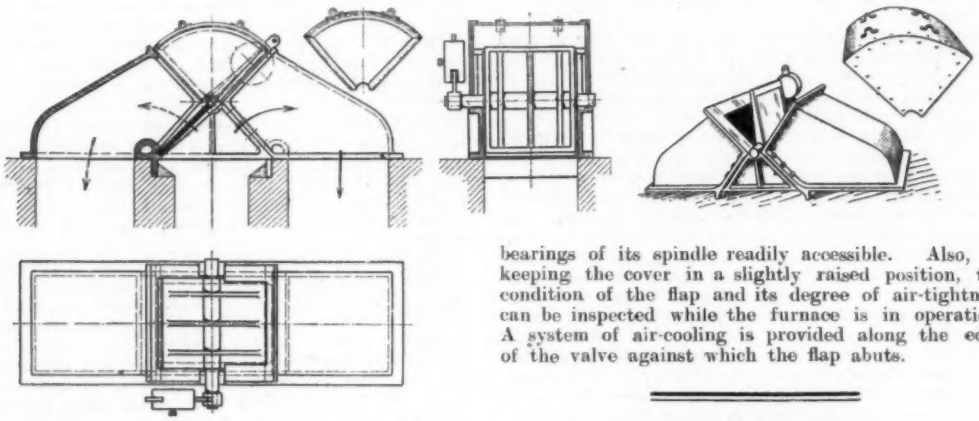
NATIONAL ALLOYS, LIMITED, Alitor Foundry, 38, The Hill, Ilford.—A booklet issued by this company deals with their various alloys and specialities. Notable among these are "Ivanium," an aluminium casting alloy; "Cupranium" non-corrosive copper alloys for casting; and "Ilford metal," an aluminium alloy introduced as a second quality to the "Ivanium" alloy.

J. W. & C. J. PHILLIPS, LIMITED, 23, College Hill, Cannon Street, London, E.C.—This company have forwarded a catalogue relating to the well-known Bristol electric pyrometers for indicating and recording high temperatures. The catalogue is a well-prepared and instructive publication, of interest to all up-to-date foundrymen. We have also received from this company illustrated pamphlets, etc., relating to Rockwell furnaces working with gas and oil, for melting and forging purposes, a considerable variety being dealt with in the different bulletins.

Foundry Plant and Equipment.

Reversing Air Valve for Regenerator Furnaces.

Many of the reversing air valves for regenerator furnaces at present in use, while simple and fairly reliable in themselves, have the drawback that the valve is not visible from outside, and is therefore somewhat inaccessible, especially when renewal comes into question, the whole casing having sometimes to be removed. The Tigler Maschinenbau Gesellschaft, of Meiderich, Duisberg, Germany, have recently brought out an improved form of valve, known as the "Simplex," in which these drawbacks are claimed to have been overcome. As will be seen from the accompanying illustration, taken from the "Zeitschrift des Vereines Deutscher Ingenieure," the design dispenses with the usual cylindrical extension at the top to convey the air to the valve. The side walls of the valve casing are so arranged that above the spindle of the valve flap is a space in which it is free to be turned or reversed. This space is provided with a detachable sheet-metal cover, the removal of which renders the flap and the bearings of its spindle readily accessible. Also, by keeping the cover in a slightly raised position, the condition of the flap and its degree of air-tightness can be inspected while the furnace is in operation. A system of air-cooling is provided along the edge of the valve against which the flap abuts.



SIMPLEX REVERSING AIR VALVE FOR REGENERATOR FURNACES.

Tool Grinders.

In Fig. 1 herewith is shown the "Polygon" 14 in. ball-bearing wet or dry tool grinder—an apparatus well adapted for pattern shop or machine shop. The body is a rigid box casting with a wide base which reduces vibration to a minimum. The spindle is of large diameter and is mounted on ball bearings, totally enclosed and dust proof. The wheel is securely mounted on the spindle by means of flanges of large diameter, and the tool rests are easily adjusted as the wheel wears down. The plain rest shown at the base of the machine is suitable for ordinary tool grinding, etc., and the rest shown fixed in position is useful for grinding to a given angle, the top of this rest being made to tilt to an angle of 45 deg. The hood is of special design, and has an extra opening at the back, and when desired the cover can be thrown up as shown. This is of great advantage in grinding extra long tools, etc.; it also allows two men to use the machine at one time. The interior of the body forms a water tank, and the water supply can be regulated from the finest spray to a steam by regulating flooding blocks operated by a hand wheel.

The twist-drill grinder shown in Fig. 2 is designed for a constant angle of 59 degrees, and the drill should project $\frac{1}{4}$ of its diameter from the steel lip on the V block; any desired clearance can be obtained by allowing the drill to project more or less from the lip. Any type of straight or taper shank drill can be ground. The adjusting head is fitted with internal and external screws; the internal screw is used to

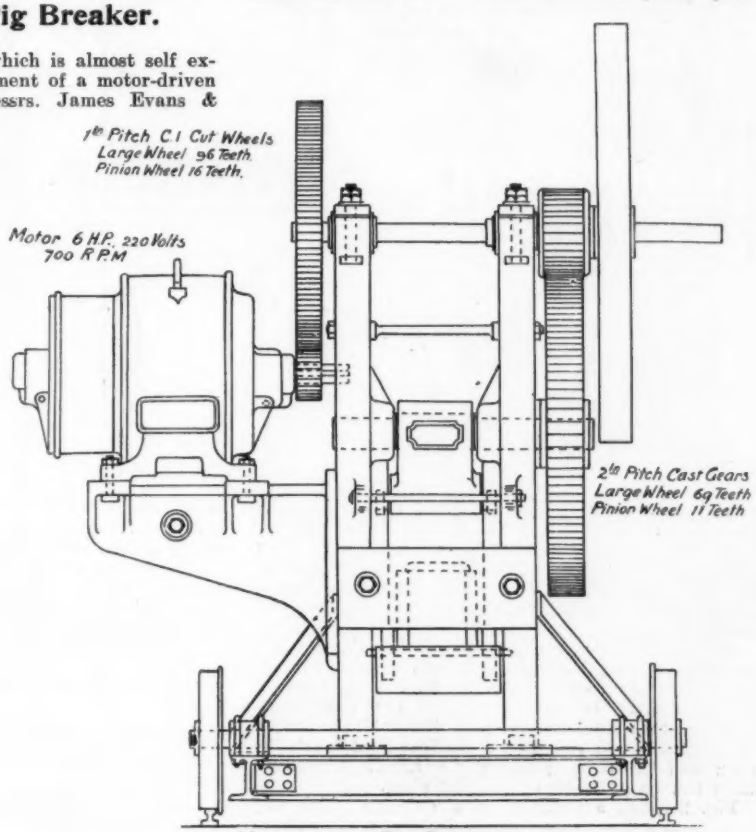
FIG. 1.—"POLYGON" TOOL GRINDER.

FIG. 2.—"POLYGON" TWIST-DRILL GRINDER.

bring the lip being ground into shape, then this position is locked by a knurled locking collar, the external screw is screwed back, the drill reversed, and the external screw used to bring the lip up to the wheel until it is back in its original position, thus making the two lips equal. The graduated slide is graduated for drills from $\frac{1}{8}$ in. to $1\frac{1}{2}$ in. diameter; no measuring is required. The makers of these tools are Messrs. Fish & Company, Polygon Works, Wellingborough.

Motor-Driven Pig Breaker.

The annexed illustration, which is almost self explanatory, shows the arrangement of a motor-driven pig breaker, supplied by Messrs. James Evans & Company, Blackfriars, Manchester, for installation at Yokosuka, to the order of the Imperial Japanese Navy. The drop cam is provided with a steel knife which drops dead on the pig, giving at each turn a stroke of great force, but practically no shock, of which last the arrangement of the motor is sufficient evidence. The stroke administered is very similar to a blow given by a punch in a punching machine. The motor, by the British Westinghouse Company, is a 6-h.p. direct-current, compound-wound, 220-volt, 700 r.p.m. machine, and was supplied complete with a unit-type control panel (ironclad). It is stated that with this breaker a ton of hematite can be broken in five minutes; the capacity of the machine, in fact, is limited only by the rate at which the pigs can be fed to it.


1/8 Pitch C.I Cut Wheels
Large Wheel 96 Teeth
Pinion Wheel 16 Teeth.
Motor 6 H.P. 220 Volts
700 R.P.M
2/8 Pitch Cast Gears
Large Wheel 69 Teeth
Pinion Wheel 11 Teeth

MOTOR-DRIVEN PIG BREAKER.

The Crafts Induction Electric Furnace.

The annexed sectional cuts show an electric steel furnace of the induction type recently designed by Mr. W. N. Crafts, President of the Crucible Steel Forge Company of Cleveland, Ohio, U.S.A., and the subjoined particulars are taken from a descriptive account published by C. H. Vom Baur in "The Iron Age":—

All improvements in electric furnaces have embodied the original position of the hearth and heating rings. This well-known position, having the hearth and rings in the horizontal plane, is also found in the typical Kjellin and Röchling-Rodenhauser induction furnaces. These furnaces inherit the one objection that they do not have a hearth of rectangular or circular shape which is wholly unobstructed, although the Röchling-Rodenhauser and Hiorth furnaces to a certain extent accomplish this by placing two rings together, in such a way as to form the figure eight where the waist of the eight is the hearth, about 7 ft. long and 18 in. wide. In these furnaces the narrow heating channels, completing the figure eight and the electric circuit, are kept free from slag by skimming bricks. Mr. Crafts, in United States Patents Nos. 1,069,923 and 1,069,924, has broken the tradition of the prevailing type of induction furnace by turning the rings 90 deg. and changing the proportions so that a plain open-hearth above the channels is obtained. This plain open-hearth is illustrated in Fig. 1, and is also shown in the vertical section, Fig. 2, and the vertical transverse section, Fig. 3, from which it is evident that the resultant hearth is plain and rectangular as in the best open-hearth furnaces. With the Crafts hearth the bottom and sides may be made just as sloping as in any open-hearth furnace and hence repairs can readily be made at the slag line between heats, which is not the case with other induction furnaces. Even so, 164 heats on one lining have been made with cold charging and 492 heats with hot charging in a 4-ton Kjellin basic furnace. The slag is entirely above the channels, and will not touch even the top of channels when the heat is poured. Where the slag is kept out of the heating channels there is scarcely any wear of the lining, showing that the chemical action of the slag causes the wearing away of the bottom and sides, and not the rotary motion of the molten metal in an induction furnace. It is therefore anticipated that these

U-shaped channels formed in the magnesite below the hearth will last through a long campaign. Another advantage of the Crafts furnace is that at no time is it possible for any slag or broken brick to enter the heating channels, which are kept full of metal even when tapping the furnace. Furthermore, since the heating channels are always filled with metal to their full capacity, the power factor of the furnace will be constant at all times during

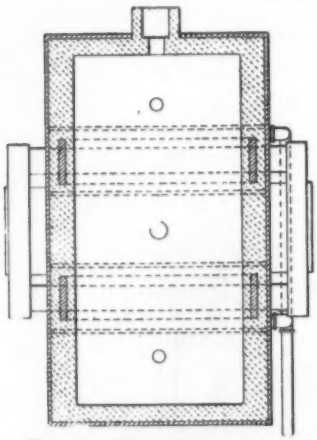


FIG. 1. HORIZONTAL SECTION OF CRAFTS FURNACE, SHOWING SIMILARITY TO OPEN-HEARTH BATH.

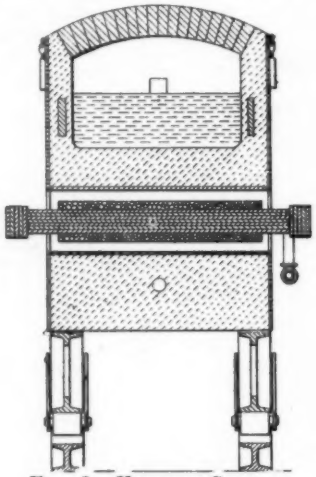


FIG. 2.—VERTICAL SECTION; CRAFTS FURNACE.

a heat, and by a proper design of the hearth and control in tilting it will be possible, if desired, to keep full current flowing even during pouring, repairing, and charging. These two electrical features will be of decided advantage in obtaining increased electrical efficiency and a better power load for the generating plant.

Since the furnace has the simplest hearth, the roof may have the simplest and strongest construction, as the transformer core and primary lie entirely beneath the bath. It is also clear that the circulation of the metal should be better, as the hotter metal in the channels will rise to the surface and meet the slag, and the refining should be rapid. Working doors can be provided on all four sides.

Fig. 2 shows a variation of the design which will operate as a two-phase furnace from any three-phase circuit having the proper frequency, by means of the well-known Scott connection. The single-phase furnace is a trifle cheaper, having only one magnetic yoke in place of two for the polyphase furnace.

Core-Drying Ovens.

Although most foundrymen know that a poor core-drying oven can easily spoil good work, it is to be feared, remarks a writer in the "Eisen Zeitung," that in many foundries such ovens are in a bad condition. Many core-makers, who should know better, consider that it does not matter whether the cores do not turn out as perfect as they might; they throw away the spoilt cores, forgetting that every one thus wasted means a certain loss of sand, binding material, labour, fuel for heating the stove, and in the handling charges. Thus, from every point of view, a good core-drying oven is an important factor in foundry work.

All such ovens must be provided with some form of heating, either direct or indirect, by gas, steam, or combustible fuel. Indirectly-heated drying ovens are those in which the combustion chamber or furnace is separate from the oven, only the hot gases passing through the latter. This system, although relatively little used, is in many quarters regarded as the best. The hot gases are conducted along brickwork flues, pipes, or other conduits, to a corner of the oven, impart their heat to the same, and pass away by a chimney. In the case of direct-heated stoves, the furnace is located below the oven. Fig. 1 shows an oven of the latter type, made by the Whiting Foundry Equipment Company, of Harvey, U.S.A. As will be seen, the furnace is, in this case, located below the floor level. In order that the flames shall not act directly

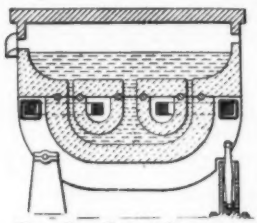


FIG. 3.—CROSS-SECTION; CRAFTS FURNACE.

on the cores, a deflecting plate or wall is provided above the furnace, a glaring heat not being conducive to the production of good cores.

Core-drying stoves are made in both fixed and portable forms, although few of the latter are in use. The fixed types are mostly lined with bricks, but the portable ovens are made of iron. A larger

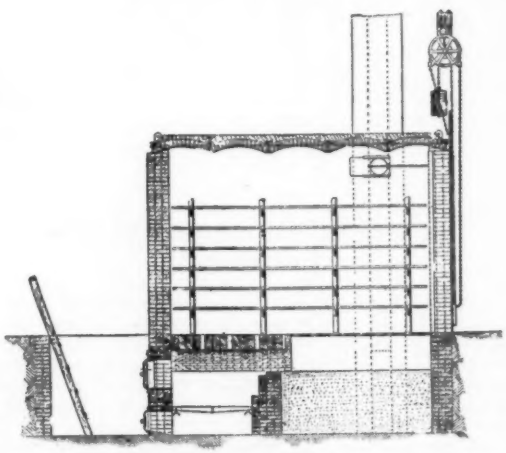


FIG. 1.—CORE OVEN, BY WHITING FOUNDRY COMPANY, U.S.A.

and more important factor in connection with core-drying ovens is their handiness and suitability for the work to be dealt with. They should not be too large for small cores, nor yet too small for large ones.

No attempt should, therefore, be made to deal with all sizes of cores in one oven, but a separate one should be employed for small and large cores. A suitable oven for medium-size cores, also made by the Whiting Company, is illustrated in plan and elevation in Fig. 2, which show that the oven is of the rotating or revolving type. Any one of the shelves for the core-plates can be turned round the central spindle, so that all the cores can be readily reached.

An old but bad plan that is still much in vogue is that of drying cores in the same oven as the moulds. The great drawback to this method is that the cores become moist before they are dried, as in mould drying a good deal of moisture has first to be got rid of in the form of steam.

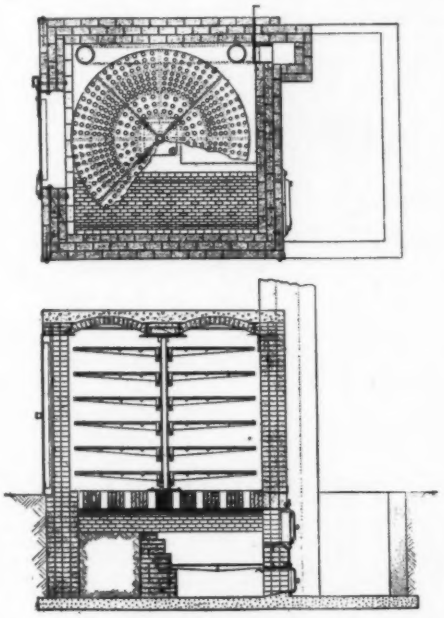


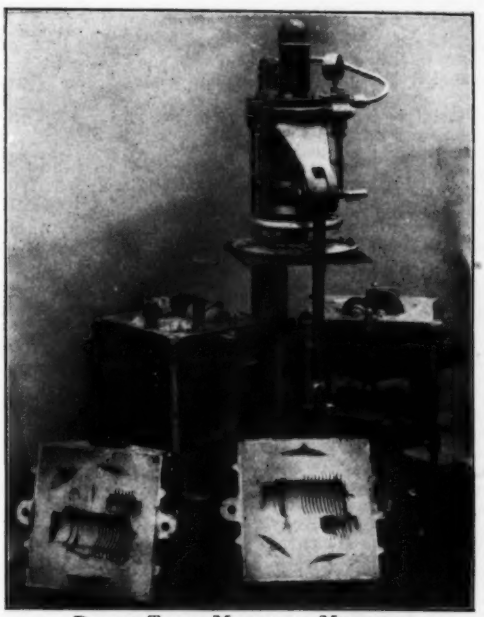
FIG. 2.—CORE OVEN, BY WHITING FOUNDRY COMPANY, U.S.A.

Double-Table Moulding Machine.

Much misconception exists regarding the advantages of moulding machines which make both halves of the complete mould; for the advantages of the process are often counterbalanced by several difficulties. The output is not always increased, but rather cut down even under the most favourable conditions, because of the special arrangement of the machine, which makes it less handy than two separate machines.

In cases where the two halves of the mould are of a different character the use of two special machines is more advisable; but this is a question for each foundry manager to settle according to circumstances and conditions of work. Herewith is illustrated a case in which a double machine is advisable. The casting is a motor-cycle cylinder, both sides being quite similar, the same boxes being required, and in which a great output is less important than the perfection in the work. In this case it is important that all the work be performed by the same man.

The machine (by the Soc. Anon. Bonvillain & Ronceray, Paris, who are represented in this country by the Universal Moulding Machine Company), is very similar to the Company's type A 5, with its ramming-piston, return-stroke piston, and regulating device of the moulding stroke by a telescopic screw. As in all their new types, ordinary packings are used instead of leathers, as those leathers if not kept in perfect working order are liable to allow considerable breakage. The columns and the piping are of the usual description, but the table is double, and can be fitted with two pattern plates. This table rests direct on the floor, and does not require any foundation work. The pattern-drawing cylinders are drilled in the tables themselves, and receive the lifting pistons, bearing the usual lifting plates and adjustable studs. This machine is simple and effective in cases similar to the one described above. It can be operated also by two men or lads when a greater output is required in the case of a simple casting.



DOUBLE-TABLE MOULDING MACHINE.

Aluminium Bronze Containing Boron.

Mr. E. D. Gleason, of New York, has recently patented a process for the use of boron in aluminium bronze. It is claimed that this alloy does not tarnish as readily as bronze without boron, and has superior physical properties. It is made in this way: Aluminium is fused in a crucible under a layer of a mixture of three parts fluor spar and one part of boric acid. A high heat is used, so that boron fluoride forms, which reacts on the aluminium and boron is reduced. This reduced boron is absorbed by the aluminium, forming an alloy. This alloy is used in the proportion of 10 parts of alloy to 90 parts of copper for making an aluminium bronze. The alloying is effected under a layer of charcoal and black oxide of manganese.

Inventions.

Applications for Patents.

An Asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

2,155. Crucible furnaces. W. Miller.
2,192.*Treating iron and steel ingots for removal of "pipes." F. Schruff.
2,385. Manufacture of ferrous alloys. Rombacher Hutenwerke and J. I. Bronn.
2,512. Face hardening of steel. C. Bingham.
2,942.*Tipping-mechanism for casting or pouring ladles. Deutsche Maschinenfabrik Akt.-Ges.
2,943.*Mould carrier or turntable for casting-machines mounted upon a vertical shaft. (Deutsche Maschinenfabrik Akt.-Ges., Germany).
3,058.*Device for inverting casting boxes. D. Liesen.
3,244. Methods of moulding and casting manganese steel. D. Carnegie.
3,290. Casting metals. C. H. Ivinson.
3,291.*Single- or multi-phase electric furnace for treating molten metal. P. Lescure.
3,339. Furnaces for the heat treatment of metals. W. A. Russell and J Lord.
3,676. Boxes for moulding and casting. J. F. Cooper.
4,480. Furnaces for heating or annealing. A. Smallwood.
4,742. Electric furnaces. J. L. Dixon.
5,147. Composition for maintaining the brightness of polished steel. J. S. Lucock.
5,197. Melting-furnace and apparatus for stirring or mixing molten material therein. I. Hall.
5,198. Regulating and controlling temperatures in melting-furnaces. I. Hall

Abstracts of British Patent Specifications recently Accepted.

1,092 (1913). *Manufacture of Manganese-bronze, or Manganese-brass, and similar Alloys.* F. Heusler, Isabella Works, Dillenburg, Germany; and the British Mining and Metal Company, Limited, 123-127, Cannon Street, London, E.C.—The claim of the patentees is as follows:—In the manufacture and production of manganese-bronze and manganese-brass, or similar alloys, the use of a manganese-aluminium-copper alloy containing about 15 per cent. to 30 per cent. manganese, and about 5 per cent. to 15 per cent. aluminium with, or without, the addition of a small quantity of other metal.

3,354 (1913). *Cast Iron and Process for Producing same.* R. Anderson, 184, Borough Road East, Middlesbrough.—Low total-carbon or refined cast iron is produced by mixing together molten, finished mild steel and molten hematite or similar low phosphorus cast iron, direct from the blast-furnace or mixer, which obviates the difficulties involved in melting steel and cast iron together in the same furnace to produce refined cast iron. The steel is preferably poured into the cast iron. A suitable proportion for many purposes is 25 per cent. molten finished mild steel to 75 per cent. molten hematite cast iron containing about 2.5 per cent. silicon. The cast iron produced has approximately the following analysis:—Total carbon, 2.50 per cent.; silicon, 2.00 per cent.; sulphur, 0.03 per cent.; phosphorus, 0.05 per cent.; manganese, 1.00 per cent.

17,116 (1913) *Foundry Moulding Machines.* C. Bouillon, 119, New Litchfield Street, Torrington, Connecticut, U.S.A.—Fig. 1 is a sectional elevation illustrating the application of the invention to a hand moulding machine; Fig. 2 is a section on the line 2—2 in Fig. 1, looking in the direction of the arrows; Fig 3 is a plan view and Fig. 4 an elevation of the guide block detached. The table and parts carried by it, including the patterns, are raised to the position shown in Fig. 1 and are locked there by pin 29. Sand is then shovelled into the flask and is rammed, after which the operator oscillates arm 44 causing oscillatory movement of the cam ring, and causing the bosses 35 to engage the rolls on the vibrating plate and impart vibratory movement to it. As there are four rolls on the vibrating plate and four bosses on the cam ring it follows that a four direction movement will be imparted to the vibrating plate. In Fig. 2 the movement of the cam ring will be in the direction of the arrow. Boss 351 engages a roll on the vibrating plate and moves it toward the right. An instant later boss 352 engages a roll and moves the plate in the opposite direction, and boss 353 engages a roll and moves the plate at right angles, that is in the direction of the top of the sheet. Almost immediately boss 354 engages a roll and moves the plate in the opposite direction, thus imparting a four direction movement to the vibrating plate and leaving the pattern in the exact centre of the slightly enlarged pattern impression in the mould. These movements of the vibrating plate are made possible by slide block 39, which reciprocates in one path of movement with the vibrating

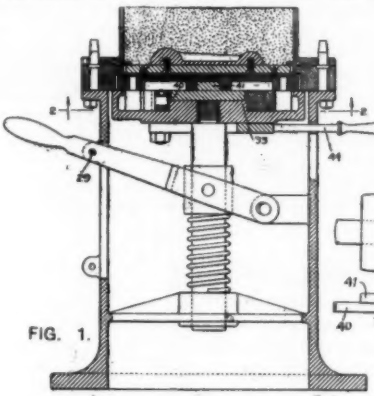


FIG. 1.

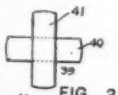


FIG. 3.

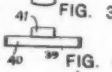


FIG. 4.

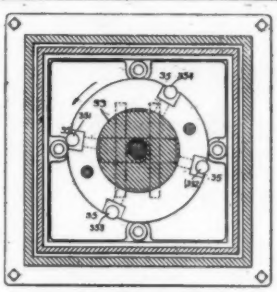


FIG. 2.

Foundry Moulding Machine.

plate, and permits the plate to reciprocate independently in a path at right angles to the first mentioned movement. When the first and second movements of the vibrating plate take place, the plate will carry the slide block through the engagement of upper arm 41 with the groove in the vibrating plate, lower arm 40 sliding in the groove in hub 33 on the table. When the third and fourth movements of the vibrating plate take place, no movement will be imparted to the slide block but the vibrating plate will slide on upper arm 41 of the slide block. After this movement of the vibrating plate, no portion of the mould is in contact with the pattern, but there is a slight space between the pattern and the mould which allows the pattern to be withdrawn without danger of dragging sand even should the sides of the pattern be vertical. This space may be varied by adjustment of the bosses on the cam ring. After the vibrating operation, the operator removes pin 29, lowers the table and parts carried by it by means of the operating lever and locks them at the lowered position by means of pin 29. The pattern is now wholly out of the mould and the flask and mould may be removed from the flask frame without possibility of contact with the pattern. The table is then raised again and the machine is ready to receive another flask.

Trade Talk.

THE offices of the Institute of Inventors are now at 20, High Holborn, London, W.C.

IT is stated that Stewarts & Lloyds', Limited, will shortly issue new shares to existing holders.

THE BUTTERLEY COMPANY, LIMITED, have presented a petition to Parliament for leave to deposit a Bill "to constitute them a company limited by shares."

MR. A. ROBERTSON, East India Chambers, 23, Leadenhall Street, London, E.C., has been appointed London and district agent for T. A. Savery & Company, Limited.

THE NATIONAL TIME RECORDER COMPANY, 5, Blackfriars Road, London, S.E., are supplying their patent check action automatic time recorders to the Metropolitan Water Board.

MESSRS. W. HOWLETT and F. G. DAULMAN, carrying on business as iron and metal founders, at 211, Station Road, Rugby, under the style of Howlett & Daulman, have dissolved partnership.

MESSRS. H. HEAPS and W. G. HEAPS, carrying on business as engineers, millwrights, and machinists, at Ann Street, Kendal, under the style of Wright, Heaps & Westwood, have dissolved partnership.

THE shareholders of the Oil Flame Furnace Company, Limited, have decided that the company be wound up voluntarily, and that Messrs. Peat be appointed liquidators for the purposes of such winding-up.

MESSRS. C. C. SMITH and C. FITZHERBERT BILL, carrying on business as engineers, at 34, Arragon Road, Twickenham, under the style of the London Scottish Engineering Company, have dissolved partnership.

THE shareholders of the Midas Steel and Engineering Company, Limited, have passed a resolution to the effect that the company cannot, by reason of its liabilities, continue its business, and that it be wound up voluntarily.

MR. W. S. WAITE, of Derwentwater Chambers, Sandhill, Newcastle-on-Tyne, has been appointed sole agent for the Tyne and Tees district for Messrs. David Rollo & Sons, Liverpool, shipbuilders, engineers, ship repairers, etc.

THE partnership heretofore subsisting between Messrs. T. A. Swallow and T. L. Gray, carrying on business as engineers, at 18, Grainger Street West, Newcastle-upon-Tyne, under the style of Swallow & Gray, has been dissolved.

MESSRS. J. E. AMBLER and W. B. HARGREAVES, carrying on business as engineers and brassfounders at the Phœnix Engineering Works, Collingwood Street, Colne, under the style of Ambler & Hargreaves, have dissolved partnership.

A CO-OPERATIVE movement is on foot on Tees-side with the view to improving and making the district better known as one with exceptional facilities for the smaller iron and steel industries, such as exist at Sheffield and Birmingham.

THE directors of Vickers, Limited, propose to increase the ordinary share capital of the company by £1,110,000 to £5,550,000 equal to one share for every four existing shares. These shares will be offered to the shareholders at 28s.

MESSRS. A. BLYDE & COMPANY, of the Wallace Steel Works, Sheffield, have received an order for their "Crutch Brand" of cast tool steel from the County Borough of Middlesbrough for the 12 months ending March 31, 1915.

THE partnership heretofore subsisting between Messrs. A. C. Harris and S. Keats, carrying on business as engineers and machinists, at Portland Road, Leicester, under the style of the Gripper Manufacturing Company, has been dissolved.

THE co-partnership of Barr and Company, coppersmiths and brassfounders, Greenock, having dissolved by the death of Mr. John Barr, the remaining partner, Mr. James B. Duff, has acquired the business and name in partnership with Mr. John D. Barr, son of the deceased.

MR. WALTER CROOKE, formerly manager of the Cargo Fleet Iron Company, Limited, of Middlesbrough, and lately of the Shotton Works of John Summers & Sons, Limited, has opened offices as a consulting iron and steel works engineer at Queen Anne's Chambers, Westminster, London, S.W.

MR. E. DUISBERG, manager of the small tools department at the works of Messrs. Goodchild & Macnab, has resigned that position. He has opened an office at Victoria Mansions, 28, Victoria Street, London, S.W., where he will specialise in small tools, machine tools, twist drills, etc.

AT a meeting of the shareholders of Poulson's Foundry Specialities, Limited, a resolution was passed to the effect that the company cannot, by reason of its liabilities, continue its business, and that it is advisable to wind up the same. Mr. J. Thompson, of East Parade, Leeds, has been appointed liquidator.

GEO. BRADSHAW & COMPANY, LIMITED, metal merchants, 64, Cross Street, Manchester, have taken up the sub-agency for the sale of ferro-manganese and spiegel made by the Carlton Iron Company, Limited, for the districts of Yorkshire (south of the City of York), Lancashire, Cheshire, North Lincolnshire, and North Wales.

MESSRS. EEKHOUT & COMPANY, of 82, Gordon Street Glasgow, have been appointed sole representatives in Scotland, of Veithardt & Hall, Limited, 41, Eastcheap, London, E.C., and of Burstinghaus & Company, Limited, 41, Eastcheap, London, E.C., for the sale of German pig-iron and Continental iron and steel products generally.

BOLCKOW, VAUGHAN & COMPANY, LIMITED, Middlesbrough, have appointed Mr. Thomas S. Smeeth as their agent in the West Riding of Yorkshire and the Eastern portion of Lancashire for the sale of their Cleveland and Claylane brands of pig-iron, "B.V." hematite, spiegeleisen and ferro-manganese, steel plates, billets, bars, rails and railway material.

THE firm of John Glover & Sons, brassfounders and electrical engineers, Muslin Street, Bridgeton, Glasgow, of which Mr. John Glover, Mr. David Crawford Glover, and Mr. William Hendry Glover were the sole partners, was dissolved as at December 31 by the retirement of the first-named. The remaining partners will continue the business under the same style.

FOR a considerable time the steel foundry at the Hamilton Works of Arch. Baird & Son, Limited, has not proved equal to the demands made upon it, and extensions were imperative; but, rather than add to the existing plant, the company decided to erect an entirely new foundry to assist the older plant, and it is hoped to have this and other extensions completed within the course of the next few months.

THE partnership heretofore subsisting between Messrs. F. A. B. Lord, F. W. Dennis, and J. E. Hood, carrying on business as engineers and iron and machine merchants and agents, at 49, Queen Victoria Street, London, E.C., under the style of W. F. Dennis & Company, has been dissolved so far as concerns Mr. F. W. Dennis. Messrs. F. A. B. Lord and J. E. Hood will continue to carry on the business under the style of W. F. Dennis & Company.

THE pattern shop fortunately escaped the fire which recently completely gutted the machine shops at the Empress Works, Johnstone, N.B., of Clifton & Baird, Limited, and this department is still in full operation. The company were able to acquire the use of machine shops in the immediate vicinity, where their own men are being employed on orders of an urgent nature. It is, however, hoped to be able to start up at any rate a portion of the old works in a month's time.

THE CARNTYNE FOUNDRY, Parkhead, Glasgow, formerly in the occupation of Messrs. Campbell, Binnie & Company, but which has lain idle for rather more than three years, has been acquired by Steel Castings, Limited, who are engaged on the restoration of the buildings and the installation of a modern steel foundry plant, a portion of which it is hoped to start up within the next two months. The initial melting plant will be equal to the production of castings up to 10 tons in weight.

BEFORE the Sheffield Branch of the British Foundrymen's Association, and members of the Sheffield Society of Engineers and Metallurgists, who were present by

invitation, a lecture, profusely illustrated by lantern slides, was delivered at the Applied Science Department of Sheffield University, on Monday, March 23, by Mr. J. W. Kershaw, M.Sc., B.Eng. The subject was "Power Generation and the Needs of To-day." Mr. Thos. H. (President of the local Branch of the Foundrymen's Association) occupied the chair.

THE partnership heretofore subsisting between Messrs. C. A. Goodall and W. J. B. Leech and Clayton, Son & Company, Limited, carrying on business as manufacturers of elevating and conveying machinery, builders of furnaces and retort benches and general engineers, at Pepper Road, Hunslet, Leeds, under the style of Leech, Goodall & Company, has been dissolved by the retirement of Mr. Leech. Mr. C. A. Goodall and Clayton, Son & Company, Limited, will continue to carry on the business at the same address and under the same style.

THE first practical recognition of the debt which metallurgists owe to the late Dr. Henry Clifton Sorby, the eminent Sheffield geologist and founder of metallography, was forthcoming at the Cutlers' Hall on February 28, when the first "Sorby" lecture was given under the auspices of the Sheffield Society of Engineers and Metallurgists. The subject was "Structural Analogies Between Igneous Rocks and Metals," and the lecturer, Prof. W. G. Fearnsides, M.A., F.R.G.S. (first occupant of the Sorby Chair of Geology at the Sheffield University), took the opportunity of paying a tribute to the pioneer work and researches of the late Dr. Sorby.

MR. JAMES KERR, of the Etna Iron and Steel Works, Motherwell, informs us that on December 31 last he became the sole partner of the Etna Iron and Steel Company, and he then assumed as partners his son, Mr. James Kerr, junr., and Mr. William Cunningham, who have both been for many years closely associated with him in the management of the business, the former as works manager and the latter as commercial manager. It has now been found desirable to convert the business into a private limited company under the style of the Etna Iron & Steel Company, Limited. This step does not involve any change in the management or conduct of the business. Mr. James Kerr retains the control as managing director, and the other gentlemen named have been appointed directors in charge of the departments formerly under their supervision.

AT the works of the Brightside Engineering and Foundry Company, Limited, on March 14, a serious accident occurred which ultimately resulted in the loss of three lives, other men also being injured. A chilled ram, of about three tons weight for a press was being teemed, and when the operation was nearly completed a column of molten metal shot upwards, and, spreading like a fan, descended upon the workmen. The woodwork of the steam crane which was above the mould caught fire, but the crane-driver ran the crane to the other end of the shop and extinguished the flames. There were between 50 and 60 men in the shop at the time, and about a dozen either engaged in the casting of the ram, or standing close by. The precise cause of the accident is not known, but one suggestion put forward is that the molten metal forced its way through a joint and came into contact with the brickwork at the bottom of the pit, which was probably damp. There was no report, the metal being simply shot into the air, though witnesses stated that this was preceded by a hissing noise. At the inquest subsequently, careful inquiry by the Sheffield Coroner, aided by the Factory Inspector for the district, failed to establish the cause of the accident. Mr. F. W. Firth, managing director of the Company, said that throughout the 22 years he had been at the works similar work had been done, and there had been no other fatal accidents in that period. He had personally investigated the accident, and found that quite ordinary work was being done with which the men were quite familiar. He had had the mould in which the casting was being made dismantled with a view to ascertaining why the molten metal had got into the box and caused the explosion, but he could not find the reason, and could give the jury no explanation why the metal blew up. There was no evidence of neglect.

Personal.

MR. W. V. WAITE, joint managing director of Broom & Wade, Limited, engineers, High Wycombe, has resigned that position.

MR. W. H. RUDGE, secretary of Fletcher, Russell & Company, Limited, of Warrington, has been elected a director of the company.

THE late Mr. E. A. Lazarus-Barlow, a former chairman of the British Thomson-Houston Company, Limited, left £226,332 gross, and £221,315 net.

MR. T. H. WARBURTON, of Sheffield, has been appointed steelworks manager at the Monk Bridge Iron and Steel Company's works, Leeds.

THE late Mr. J. H. R. Tasker, of Baslow, Derby, chairman of Tasker's Engineering Company, Limited, of Sheffield, left estate of the gross value of £28,215, of which £21,309 is net personalty.

THE RIGHT HON. SIR FRANCIS HOPWOOD has been elected to a seat on the general board and executive committee of the National Physical Laboratory, in the place of Sir Arthur Rücker, resigned.

THE late Mr. W. T. Whitehead, a director of Whitehead & Poole Limited, engineers and pump manufacturers, of Radcliffe, left estate of the gross value of £6,421, of which £5,982 is net personalty.

WE regret to learn that Mons. P. Delalande, the secretary of the Universal System of Moulding and Machinery Company, Limited (the London representatives of Messrs. Bonvillain and Ronceray, Paris), is leaving this country. M. Delalande is well-known in British foundry circles as an authority on machine-moulding practice, having carefully studied the special conditions obtaining in Great Britain. As a member of both the British and French Foundrymen's Association he has done much to establish the present cordial relations between the two societies. We understand he is taking a commission in the French Army in the Engineers, a career in which he will doubtless maintain the popularity and esteem with which he is regarded in the vocation he is relinquishing.

MONS. P. DELALANDE.

MR. G. A. TOMLINSON, B.Sc., has been appointed chief assistant in the electrotechnic department, and Mr. G. V. Bird, B.Sc., assistant in the engineering department at the Borough Polytechnic Institute, London, S.E.

THE Council of the University of Sheffield have appointed Mr. L. Southerns, B.A. (Cambridge), B.Sc. (London) to the post of assistant lecturer and demonstrator in physics, in succession to Dr. R. T. Beatty, resigned.

MR. A. O. BACKERT, the editor of our American contemporary, "The Foundry," has accepted the appointment as secretary-treasurer of the American Foundrymen's Association, succeeding Dr. Richard Moldenke who recently resigned.

MR. W. H. FLOOD, who was the manager of the electrical department of the business of the Thames Iron Works, Shipbuilding and Engineering Company, Limited, has been appointed manager of the London business of Messrs. A. & P. Steven, Provanside Engine Works, Glasgow.

THE late Mr. Benjamin Freeborough, of Park Grange, Sheffield, one of the original directors of Hadfield's Steel Foundry Company, Limited, and for some years a director of the Brightside Foundry and Engineering Company, Limited, left estate of the gross value of £18,844, net personalty £17,889.

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THE Cupola.
Evans's Rapid.

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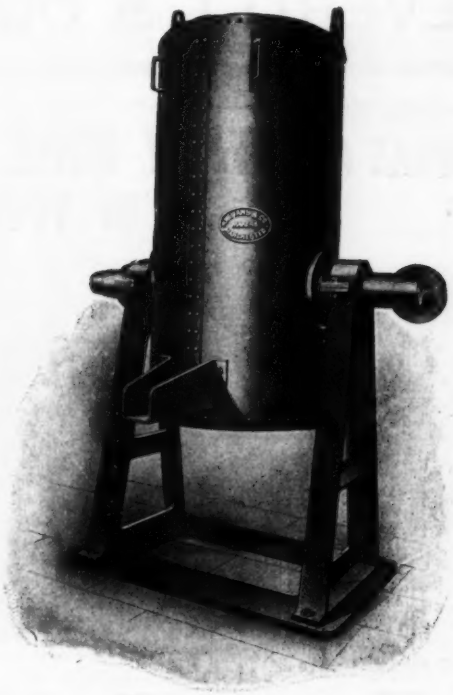

James Evans & Co.,
Britannia Works,
Blackfriars,
MANCHESTER.

Telegrams: "LADLES, MANCHESTER."

New Companies.

LATEX ENGINEERING COMPANY, LIMITED.—Capital £10,000 in £1 shares.

METALLIC ALLOYS, LIMITED.—Capital £1,000 in £1 shares (880 cumulative preference and 120 founders). Registered office: 102, Fenchurch Street, London, E.C.

MITEAR COMPANY, LIMITED.—Capital £1,250 in 750 six per cent. preference shares of £1, and 10,000 ordinary share of 1s., to carry on the business of engineers.

YETTON & BROCKETT, LIMITED.—Capital £2,000 in £1 shares, to carry on the business of brass and general metal founders and finishers, etc. The first directors are J. Yetton and W. E. Brockett.

WHITEWAY & BALL, LIMITED.—Capital £12,000 in £1 shares, to carry on the business of ironmasters, etc., and to adopt an agreement with W. Ball and M. W. Ball. The first directors are W. H. Ball and M. W. Ball.

A. C. BAMLETT, LIMITED.—Capital £28,100 in £1 shares, to carry on the business of agricultural engineers, etc. The first directors are W. Wawn, L. Parker, J. T. Farndale, G. Fentress, and H. M. Comber. Registered office: Sowerby, near Thirsk.

ASHLEY, CLIFTON & COMPANY, LIMITED.—Capital £3,000 in 2,750 ordinary shares of £1 each and 5,000 founders' shares of 1s. each, to carry on the business of engineers, founders, etc. The first directors are R. W. Ashley, G. Clifton, and A. C. W. Rogers (all permanent).

HENRY WHITHAM & SON, LIMITED.—Capital £7,000 in £1 shares, to carry on the business of steel and file manufacturers, iron masters, etc. The first directors are Mrs. S. A. Whitham and C. H. Whitham (both permanent). Registered office: 74, Arundel Street, Sheffield.

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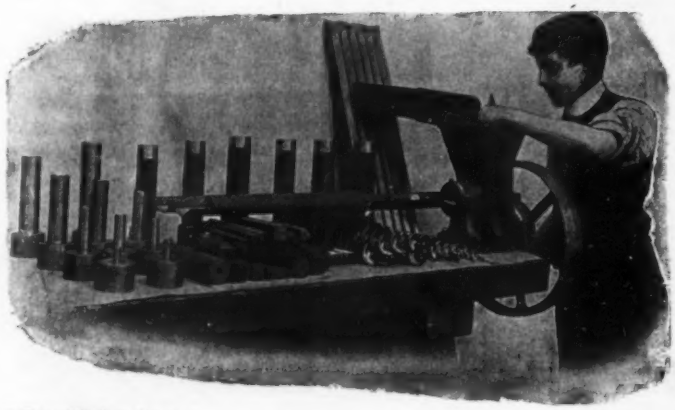
Telegrams: "PERSISTENT." Telephone No. 1134 (3 lines).

WHAT A ROTARY CORE MAKING MACHINE MEANS IN YOUR FOUNDRY:



ACCURATE CORES
($\frac{1}{32}$" sizes if required).
UNIFORM CONSISTENCY
(owing to mechanical packing).
SPEED OF PRODUCTION
(a yard of core in 15 seconds with the labour of an unskilled youth).
No Wires—No Joints—Perfect Venting.
These advantages combine to make this Machine indispensable in every Foundry.
Full particulars from -
Horace P. Marshall & Co.,
Telegrams "Specialty, Leeds." Telephone 1909. FOUNDRY SPECIALISTS, **LEEDS.**

IMPORTANT TO IRONFOUNDERS.

MOULDING— —MACHINES

FOR REPETITION FOUNDRY WORK.

Illustration of

HAND PRESS MACHINE

for Small Repetition Work, giving rapid and Economical Production.

Makers also of a

HAND RAMMING MACHINE

where a Deep Lift is required. Can be Operated by

UNSKILLED LABOUR.

MOST EFFICIENT AND ECONOMICAL IN USE.

Also Makers - - of - - ROOTS' "ACME" BLOWERS.

FULL PARTICULARS FROM—

Samuelson & Co., Ltd., Banbury,

ENGLAND.

SEE OUR ADVERTISEMENT EVERY ALTERNATE MONTH.

Deaths.

Mr. Andrew Taylor, a director of Grant, Ritchie & Company, Limited, engineers, Townholm, Kilmarnock, died recently, aged 74 years.

The death has occurred suddenly of Mr. Edward Towers, of 27, Brandling Park, Newcastle, consulting engineer, in his 47th year.

Mr. T. Douglass, of Kensington Terrace, Newcastle, and head of the firm of Douglass Bros., Limited, of the Globe Iron Works, Blaydon, has died at Warkworth.

Mr. Bryce Crawford, of the firm of Crawford & Thomson, ironfounders, Greenock, died at Dunoon on March 2. The deceased, who was 73 years of age, had been in indifferent health for some time.

Mr. Peter Turnbull, head of the firm of P. Turnbull & Sons, engineers, Sanquhar, died on March 3. The deceased took an active part in public affairs, and was a member of the Town Council for the long period of 26 years.

The death is announced from Rheinhausen, Germany, at the age of 48 years, of Herr Ernst Lange. The deceased was a recognised authority on the production of pig-iron, and was the manager of the Krupp Company's Friedrich-Alfred Hutte at Rheinhausen.

The death took place recently of Mr. W. H. Johnson, of Woodleigh, Dunham Massy, the managing director of the firm of Richard Johnson, Clapham & Morris, Limited, of Manchester. He was in his 65th year, and had for nearly half-a-century been actively identified with the commercial life of Manchester.

Mr. Arthur Henry Cooper, eldest son of Mr. Arthur Cooper, managing director of the North-Eastern Steel Company, Limited, of Middlesbrough, died at Colwyn Bay, North Wales, on March 16, after a long and painful illness. The deceased gentleman, who had reached his 40th year, began his career at the North-Eastern Steelworks, and after being manager of the Clarence Works of Bell Brothers, Limited, was elected managing director of the Partington Steel and Iron Company, Limited, of Irlam, Manchester.

We regret to learn of the death recently of Mr. Erwin Starr Sperry, editor and publisher of our American contemporary "The Brass World and Platers' Guide." Mr. Sperry was born in Ansonia, Connecticut, on February 28, 1866, and received his early education at the Ansonia and Derby High Schools, graduating from the latter in 1884. He subsequently attended the Sheffield Scientific School of Yale University from which he was graduated in 1887. He then secured the position of assistant instructor in Chemistry under Professor H. L. Wells, and later, in 1891, he went to Bridgeport as chemist for the Aluminium Brass and Bronze Company, and was afterwards superintendent of the Waldo Foundry. He therefore acquired a fundamental knowledge of the theory and practice of working in metals which eminently fitted him for the task of founding the paper which he has made so well known.

FANS AND BLOWERS AND OTHER FOUNDRY MACHINERY FOR SALE.

BARGAINS FOR PROMPT CASH.

No. – Root's Blower "Acme" for 20 smiths' fires.
One ditto, with high-speed Vertical Engine combined.
Thwaites Roots Blower, 11½" discharge.
"B" Roots Blower by Alldays.
Foundry Blowing Fan, 36" impeller, 19" discharge, also 9½" round outlet to fit on same.
14" Schiele patent Blast Fan.
Lloyd's patent Blowing Fan for 50 smiths' fires.
New Roots pattern Blower, 5".
Silent Blowing Fans, 8½", 8" and 9" discharge.
Ball Mill, with drum, 2' 7" and 5' 8" outside by 1' 7" wide.
Improved Foundry Core Ovens, portable type and for fixing in wall.
4' 6" diameter UNDERGEARED LOAM MILL, with stationary pan.

CHARLES D. PHILLIPS,

MLYN & CENTRAL ENGINEERING WORKS, NEW OR', MON.

BLOFIL

THE

IRON CEMENT

(Quick or slow setting grades)

IS

THE CHEAPEST

AND

MOST RELIABLE

for all purposes.

Unaffected by oil, steam, or water.

Sole manufacturers—

RUDD & OWEN

(DEPT I)

Telegrams "Theripnene," Hull.

HULL

Telephone National 1223.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

FIRE CLAY.

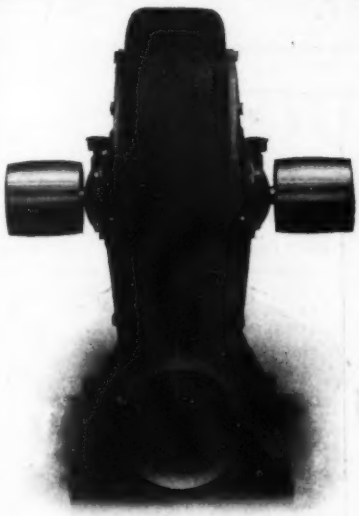
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR, nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."



TRADE SIROCCO MARK

CUPOLA FANS.

Made in eight sizes from 10-in. to 35-in. diameter, and suitable for melting ½ to 20 tons per hour at pressures from 12—30 inches Watergauge.

Cast Iron Casings and Ball Bearings.

Double Inlet. All Types of Discharge.

Write for Bulletin No. 2028F.

DAVIDSON & CO., LIMITED,

Sirocco Engineering Works,

BELFAST.

ELDERS FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.

We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Collieries, Ltd., Cardiff.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining on the first day of the current month.

Pig-iron.

Cleveland.

	April 2. s.	d.
Cleveland No. 1	54	3
,, No. 3	51	9
,, No. 4 foundry	51	3
,, No. 4 forge	51	0
,, Mottled	50	9
,, White	50	9
East Coast hematite, mixed Nos. ..	61	9
Cleveland warrants	51	5

Above prices are for early f.o.b. deliveries, and as regards Cleveland iron are for G.M.B. brands. The warrant quotations are the sellers cash prices.

Scotland.

	April 2. s.	d.
Standard Foundry (Glasgow Market settlement price)	51	0
Warrants, ditto	57	4½

Makers' prices :—	s.	d.		s.	d.
Gartsherrie No. 1..	68	6	No. 3..	63	6
Coltness No. 1..	—		No. 3..	—	
Summerlee No. 1..	68	6	No. 3..	63	6
Langloan No. 1..	68	6	No. 3..	63	6
Calder No. 1..	68	6	No. 3..	63	6
Clyde No. 1..	68	0	No. 3..	63	0
Carnbroe No. 1..	66	6	No. 3..	62	6
Monkland No. 1..	61	0	No. 3..	61	0
Shotts No. 1..	63	6	No. 3..	63	6

(All deliverable alongside Glasgow.)

GlengarnockNo. 1 .	71	0	No. 3..	66	0
Eglinton No. 1..	62	0	No. 3..	61	0

(All deliverable alongside Ardrossan.)

DalmellingtonNo. 1	63	0	No. 3..	61	0

(Deliverable alongside Ayr.)

Carron No. 1..	69	0	No. 3..	64	0

(F.a.s. Grangemouth.)

Lancashire.

	s.	d.	s.	d.
Lancashire No. 3 foundry f.o.t.	—		55	0
Lincolnshire No. 3 foundry ..	56	0	56	6
Derbyshire No. 3 foundry ..	—		57	6
Staffordshire No. 3 foundry ..	—		57	6
Cleveland No. 3 foundry ..	—		60	0

(All delivered equal Manchester.)

Scotch No. 3	Gartsherrie	68	0	68	6
	Glengarnock	66	0	70	0
	Eglinton	65	0	65	6
	Summerlee	—		67	0

(Delivered Manchester Docks.)

North-West of England.

	s.	d.	s.	d.
Bessemer mixed numbers net f.o.b.	65	6	66	0
Hematite warrant net cash ..	—		61	0
Lorn cold-blast charcoal iron ..	—		200	0

The Midlands.

		s.	d.	s.	d.
Staffs.	Common forge ..	50	0	51	0
	Part Mine forge ..	51	0	52	0
	Best All Mine ..	85	0	90	0
	Cold Blast	—		125	0

Strong forge, about 1s. less than grey forge; Mottled and White, about 2s. less than forge; Foundry No. 3, 3s. to 5s. above forge; No. 1 and No. 2, from 1s. 6d. to 2s. above No. 3; No. 1, about 2s. above No. 2.

Northampton foundry	—		59	0
North Staffs. foundry	61	0	62	0
Derby foundry	58	0	59	0
Nottinghamshire foundry ..	66	0	67	0
Leicestershire foundry	—		59	0
Shropshire Cold-Blast	—		125	0

(Delivered South Staffordshire Works, net cash monthly.)

Lincolnshire.

	s.	d.	s.	d.
Forge	50	6	51	6
Grey forge..	50	6	51	6
Basic	51	6	52	6
No. 3 foundry	51	6	52	6
No. 4 foundry	51	0	52	0

F.o.t. Makers' works.

South Wales.

	s.	d.	s.	d.
Welsh Hematite	67	6	68	0

Ferro-Alloys.

Net, Delivered Sheffield Steel works.

	£	s.	d.	£	s.	d.
Ferro-chrome : 4/6% carbon. Basis 60%, scale 10s. per unit. Per ton	21	0	0			
Ferro-chrome : 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	19	0	0			
Ferro-chrome : 8/10% carbon. Basis 60%, scale 8s. 6d. per unit. Per ton	17	15	0			
Ferro-chrome : Specially refined, guaranteed maximum 2% carbon, broken to small pieces for use in best quality crucible steels. Basis 60%, scale 22s. per unit. Per ton	49	15	0			
Ferro-vanadium : 33/40% Va., per lb. of Va. contained in the alloy ..	0	10	0			
Ferro-silicon : 45/50%. Basis 50%, 5s. scale per unit .. Per ton	11	5	0			
Ferro-titanium : 15/18%, per pound, flat	0	0	6½			
Ferro-molybdenum : 70/80% Mo. per pound of Mo. contained	0	10	9			
Ferro-phosphorus : 20/25%. Per ton	13	10	0			
*Ferro-manganese 80%	9	0	0			
,, export..	8	5	0	8	10	0

* F.o.b. Liverpool.

Iron Castings.

Cleveland.

	£	s.	d.	£	s.	d.
Columns (plain)	7	7	6 to	7	12	6
Pipes, 1½ to 2½ in. ..	6	5	0	6	10	0
,, 3 to 4 in. ..	5	17	6	6	0	0
,, 5 to 8 in. ..	5	12	6	5	15	0
,, 10 to 16 in. ..	5	15	0	—		
,, 18 to 24 in. ..	5	15	0	—		
Chairs	4	5	0	4	6	0
Floor plates (open sand)	3	10	0	3	12	6

(At works.)

Non-Ferrous Metals.

	April 2. £	s.	d.
Copper.			
Standard Cash	65	17	6
Three months	66	2	6
Electrolytic	67	10	0
Tough	69	15	0
Best selected	70	0	0
Tin.			
Foreign Straits Cash	171	5	0
,, ,, Three months ..	172	15	0
English Ingots	171	10	0
Bars	172	10	0
Refined	175	10	0
Spelter.			
Silesian	21	12	6
Specials	22	7	6
Hard	18	10	0
British	22	2	6
Lead.			
Soft foreign	18	5	0
English	18	10	0
Antimony.			
Regulus	28	10	0
Aluminium.			
Virgin Metal, 98/99% .. per ton	85	0	0
***Chromium (Metallic).**			
98/99% purity. per lb. 2s. 4½d. to	0	2	6
***Nickel.**			
In cubes, 98/99% purity Per ton	169	0	0
***Tungsten Metal.**			
96/98% purity per lb. 2s. 5½d. to	0	2	6
***Molybdenum Metal.**			
96/98% purity.. per lb. 10s. 6d. to	0	11	0
***Cobalt Metal.**			
97% purity .. per lb. 6s. 9d. to	0	7	0
Quicksilver			
75 lb. bottle	7	0	0

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.

	s.	d.		s.	d.
Steel scrap, heavy melting ..	46	0	to	48	0
Iron scrap cast (cupola metal)	53	0		55	0

London (f.o.b.).

Heavy steel	51	0			
Light ,, ...	35	0			
Heavy cast	50	0			

Non-Ferrous Scrap.

London merchants quote, delivery free, and subject to market fluctuations :—

	J. B. Garnham and Sons. £	s.	d.	A. Joseph. £	s.	d.
Brass	42	0	0	41	10	0
Clean copper	60	0	0	58	0	0
Braziery copper ..	54	0	0	52	0	0
Old lead	17	17	6	16	10	0
Tea lead	16	17	6	15	0	0
Old zinc	16	0	0	16	5	0
Hollow pewter ..	130	0	0	125	0	0
Black pewter (shaped)	70	0	0	80	0	0
Gun metal	54	10	0	53	0	0
Aluminium (cast) ..	50	0	0	—		
,, (cuttings)				62	0	0

Stocks.

Pig-Iron in Public Store.

	April 1. Tons.	Inc. + or Dec. — since April 1, 1913. Tons.
Connal's at Glasgow Scotch	1,000	No change.
Ditto other makes ..	12	—83
Connal's at Middlesbrough	119,341	—93,785
Connal's at Middlesbrough, hematite ..	—	No change.
West Coast hematite..	8,147	—20,946

Metals.

Copper, Europe and afloat	26,729	—20,845
Tin, London, Holland, U.S.A. and afloat	18,539	+6,422

Coke.

Middlesbrough.

	s.	d.		s.	d.
Gas Coke	—		to	13	6
Foundry Coke	20	0		22	6
Furnace coke	—			17	0

Newcastle-on-Tyne.

FOUNDRY COKE—	F.o.b. Dunston. s.	d.
Original Garesfield	20	6
Mickley	20	6
Stella Garesfield	20	6
Priestman's Garesfield	21	0
Consett Garesfield	20	6
Newcastle gas coke	12	3

Cardiff.

	s.	d.		s.	d.
Special foundry coke ..	25	0	to	27	0
Foundry coke	20	0	to	23	0
Furnace coke	17	0	to	19	0

Leeds.

Furnace coke	—	at ovens.	

Birmingham.

Foundry coke	35	0	to	37	6
Furnace ,, ...	15	9	to	17	0
Gas ,, ...	13	6	to	14	6

Glasgow.

Foundry coke	25	0	to	27	0
Furnace ,, ...				18	6
Gas ,, ...				10	6

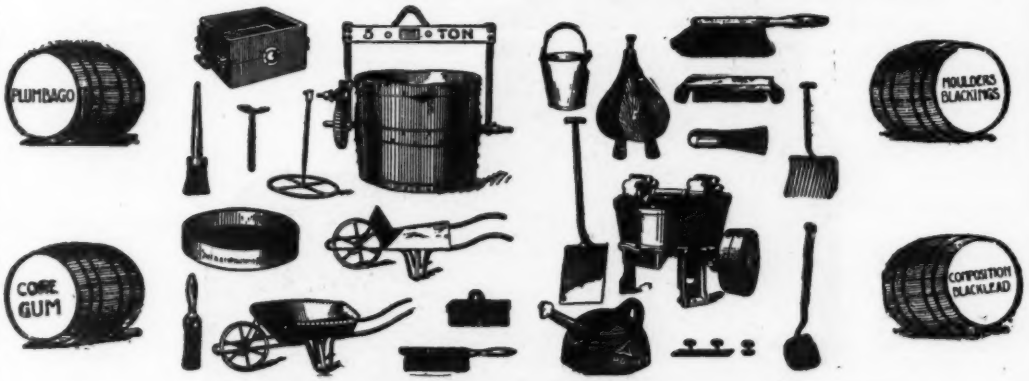
London.

Foundry coke	—		
Gas ,, ...	19	2	

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



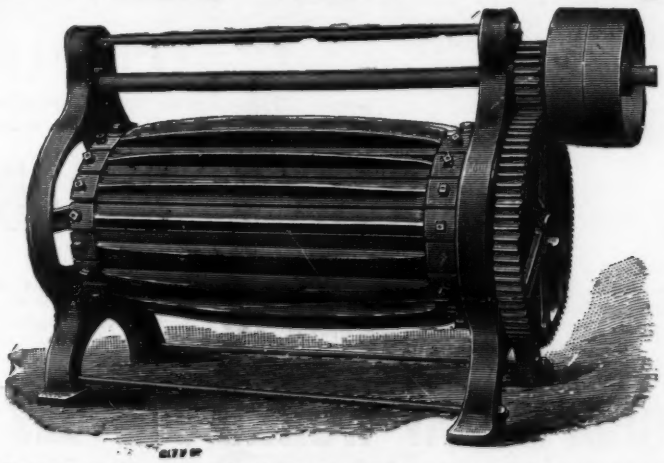
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



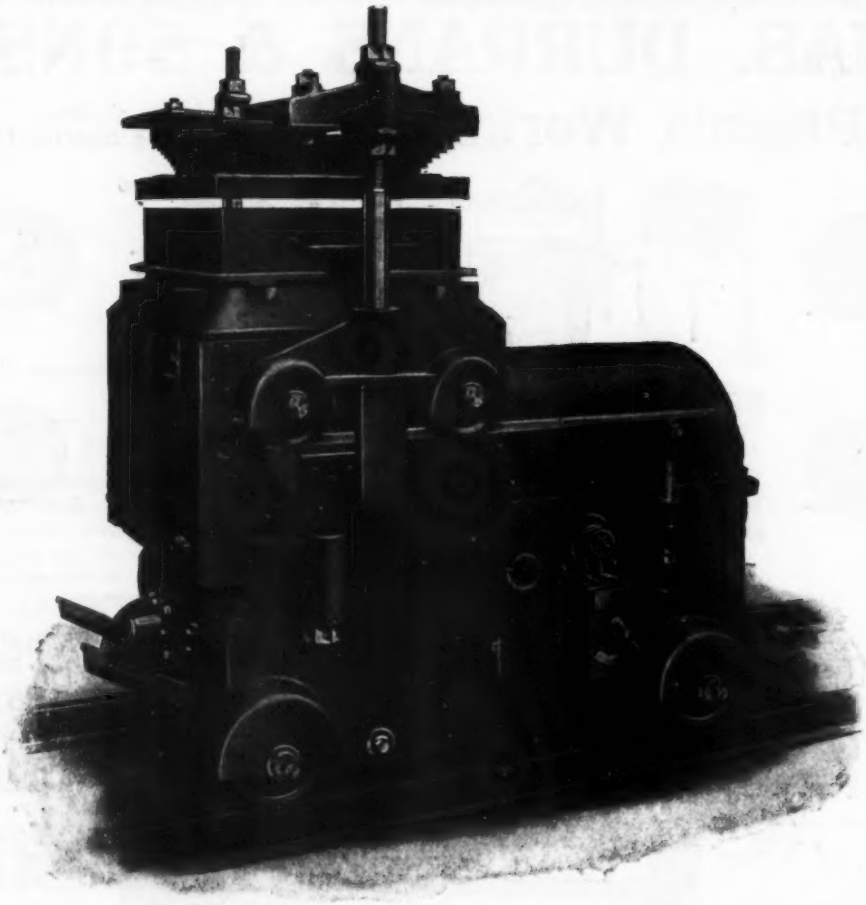
These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

USE YOUR ELECTRIC POWER FOR MOULDING.



THE NEW PORTABLE ELECTRICALLY-OPERATED MOULDING MACHINE.

SPEED. ACCURACY. DURABILITY.

No sand frame required. Strickling of surplus sand from moulding box done away with. The man fills the box with sand, pulls over rammer head and depresses treadle — the electric motor does the rest. There is no faster or simpler machine made. Let us quote for a machine to suit your requirements; a blue print or sample casting is all that we require.

THE LONDON EMERY WORKS Co., PARK WORKS,

TOTTENHAM, LONDON, N.

Nearest Passenger Station, Park, G.E.R. Telephone: Tottenham, 158.

SITUATIONS VACANT AND WANTED.

YOUNG MAN, with 12 years' experience of Foundry work, and 1 year's travelling experience in the Midlands, would like a berth as Midland Counties REPRESENTATIVE with a Firm of Foundry Requisite Manufacturers, on salary and commission. Expenses very low, as advertiser has own motor cycle.—First-class references on application to Box 508, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

FOUNDRY FOREMAN, total abstainer, seeks position Marine Engine, General Jobbing, and Moulding Machine practical experience. Mix iron and semi-steel by analysis. Ten years Foreman in United States. Best of references.—"FOREMAN," 135, Vernon Street, Belfast.

ENERGETIC young MAN, who has a thorough practical and technical knowledge on all branches of Foundry Work, Iron and Brass, having passed technical training on all Foundry Work and awarded Diploma for same, seeks situation as FOUNDRY MANAGER or FOREMAN, home or abroad. Age 34.—Apply Box 500, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

FOR SALE AND WANTED.

CORE GUM. ROSIN. CORE GUM. ROSIN.

IT will Pay you to write me for Samples and Prices. EDGAR KENYON, Direct Importer.

5, Carr Street, Blackfriars Street, Manchester.

TO UTILIZE your OLD SAND, mix, grind, and prepare it at the Lowest Cost by HALL'S INVINCIBLE SAND MIXERS. Universal success. All information free to Foundry Managers.—Apply C. E. V. HALL, Stirling Chambers, Sheffield.

TO BRASS FOUNDERS AND OTHERS.—For SALE, almost new HAND MOULDING MACHINE. SAND MILL. ROTARY SIEVE, First-Class GAS ENGINE, LATHES, and other Machines.—Apply Box 490, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

TO BUSINESS MEN.

The Decentralisation of Industrial Labour.

The opportunities offered by certain Provincial Towns to Manufacturers requiring to **remove their works** or to **establish new factories or warehouses** are dealt with in detail in a new publication, "**Industrial Progress,**" which may be obtained gratis, at G.N.R. Stations and Offices, or post free from the Superintendent of the Line, Dept. 13, G.N.R., King's Cross Station, London, N.

NAISH & CROFT,

Consulting Metallurgists and Analytical Chemists.

— SPECIALISTS IN FOUNDRY WORK. —

Laboratory for all kinds of Metallurgical Investigations.

ANALYSES. MICROGRAPHS. MECHANICAL TESTS.

When you have trouble write us. Fees on application. Special Terms for Contract Work.

Address : **150, ALMA STREET, BIRMINGHAM.**

London Office : 9 & 10, Fenchurch Street.

FOR A PERIOD OF OVER TWENTY-FIVE YEARS THE REPUTATION OF

FRODAIR SPECIAL PIG-IRONS

has been steadily growing. Their excellence is acknowledged and acclaimed by leading Engineers and Ironfounders, because they are easily **MELTED, CAST** and **TOOLED,** ensure **REGULARITY** and remarkable **DURABILITY,** and shew genuine **SUPERIORITY** and **ECONOMY.**

CYLINDERS, ENGINE PARTS, VALVES, ROLLS (chilled and grain), HYDRAULIC WORK, FIRE AND ACID-RESISTING CASTINGS, MALLEABLE CASTINGS, and other important work *shew a marked improvement when cast with* **FRODAIR IRONS.**

Write for further particulars, etc.,

THE FRODAIR IRON & STEEL Co., LTD.,

FENCHURCH HOUSE, LONDON, E.C.

Telegrams: "Frodair, London."

Stamped Brass Letters.

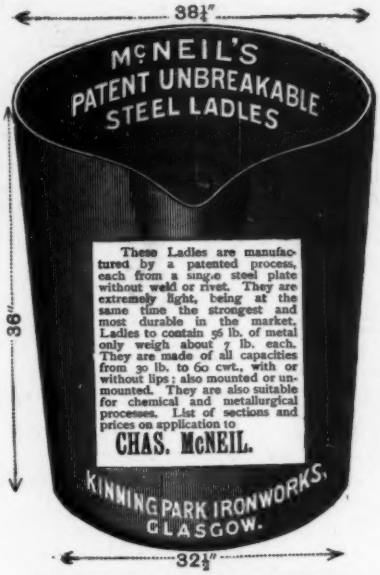
All kinds of Letters for Pattern-making and Foundries supplied from stock at very advantageous prices.

Solid (cast) Brass Letters.

Walton & Co.,

66-68, Slaney Street,

Birmingham.


38½"
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL.
KINNING PARK IRONWORKS,
GLASGOW.
36"
32½"

Can also be made in Aluminium.

WHITTAKER'S IMPROVED MOULDING MACHINE

By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.

The most complete and efficient machine hitherto introduced to Engineers.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

ROPE & BELT PULLEYS.

WM. WHITTAKER & SONS, LTD.,

SUN IRON WORKS, ***OLDHAM.***

Index to Advertisers.

Addresses, Telegraphic Addresses, and Telephone Numbers.

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256	Bradley, T. & I., & Sons, Ltd.	Darlaston	Bradley, Darlaston	—
	Britannia Foundry Co.	Coventry	Stoves, Coventry	251
257	British Aluminium Co., Ltd.	109, Queen Victoria Street, S.E.	Cryolite, London	4315 London Wall
260	British Binderit Co., Ltd.	317, High Holborn, London, W.C.	Bindercomp, Holborn, London	950 Holborn
265	Brinck & Hübner	Mannheim, Germany	—	—
C. iv.	Buckley & Taylor Ltd.	Castle Iron Works, Oldham	Engines, Oldham	Oldham No. 8
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256	Cumming, William, & Co. Ltd.	Maryhill, Glasgow	Prudence, Glasgow	P. O. M. 25
311	Davidson & Co., Ltd.	Belfast	Sirocco, Belfast	4341 Belfast
255	Davies, T., & Son	West Gorton, Manchester	Tuyere, Manchester	70 Openshaw
313	Durrans, Jas., & Sons	Penisone, nr. Sheffield	Durrans, Penistone	—
C. ii.	Dyson, J. & J.	Sheffield	Dyson's, Stannington	702 Sheffield
311	Elders' Collieries, Ltd.	Cardiff	Elder, Maesteg	10
266&309	Evans, J., & Co.	Manchester	Ladles, Manchester	2297
C. ii.	Everitt & Co.	40, Chapel Street, Liverpool	Persistent, Liverpool	1134 Central (3 lines)
315	Frodair Iron & Steel Co, Ltd.	5, Fenchurch Street, E.C.	Frodair, London	—
C. ii.	Fyfe, J. R. & Co.	Shipley, Yorks	Brick, Shipley	59 Shipley
260	Glasgow Patent Moulders Blacking Co.	26, Fleming St., Port Dundas, Glasgow	Moulders, Glasgow	—
254	Goldendale Iron Co., Ltd.	Tunstall, Stoke-on-Trent	Goldendale, Tunstall, Staffs	—
260	Gray, Thomas, E, & Co.	71, Lincolns Inn Fields, Kingsway, London, W.C.	Papplewick, London	1193 City
C. ii.	Hall, John, & Co (Stourbridge), Ltd.	Fire Clay Works, Stourbridge	Hall, Stourbridge	55 Stourbridge
260	Hislop, R. & G.	Paisley	Gas, Paisley	331 Paisley
265	Keith, James & Blackman, Co., Ltd.	27, Farringdon Avenue, London	James Keith, London	6194 H'lb'rn(4lines
256	King, Bros. (Stourbridge), Ltd.	Stourbridge	King Bros., Stourbridge	—
261	Kuhnle, Kopp & Kausch	Frankenthal-Pfalz, Germany	—	—
314	London Emery Works, Co., Ltd	Park, Tottenham	Naxium, London	99 Tottenham
310	Lowood, J. Grayson, & Co., Ltd.	Deepcar, nr. Sheffield	Lowood, nr. Sheffield	18 Stocksbridge
	Marshall, H. P., & Co.	Leeds	Specialty, Leeds	1009 Leeds
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259	McLain's System	710, Goldsmith Bldg, Milwaukee, U.S.A.	—	—
316	McNeil, Chas.	Kinning Park, Glasgow	McNeil, Glasgow	X 155
261	Murphy, Stedman & Co. Ltd.	180, Gray's Inn Road, London, W.C.	Murphites, Holb., London	4628 Holborn
	Naish & Croft	141, Whitehead Road, Aston Manor	—	—
256	Olsen, William	Cogan Street, Hull	Wm. Olsen, Hull	Nat. 1184
310	Phillips, Charles D.	Newport, Mon.	Machinery, Newport	—
C. iii	Phillips, J. W. & C. J.	23, College Hill, E.C.	Colloquial, London	10112 Central
264	Pickles, James, Ltd.	Laurel St., Leeds Rd., Bradford	Pickles, Laisterdyke	8723 Bradford
	Piftin, Ltd.	2, Fen Court, Fenchurch Street, E C.	Russesco, London	11230 Central
310	Rudd & Owen	Hull	Therpinene, Hull	1223 Nat.
	Samuelson & Co., Ltd.	Banbury	Samuelson, Banbury	—
253	Standard Sand Co., Ltd.	Mansfield	Standard Sand Co., Mansfield	201 Mansfield
257	Stewart, D., & Co., Ltd.	London Road Iron Works, Glasgow	Stewart, Glasgow	71 P.O. Bridgton & 3243 Bridgton (N)
C. iii.	Tilghman's Patent Sand Blast Co., Ltd.	Broadheath, nr. Manchester	Tilghmans, Altrincham	14
262	Thwaites Bros., Ltd.	Bradford	Thwaites, Bradford	3459&3460 Br'd'f'r
257	Walker, I. & I.	Rotherham	—	—
316	Walton & Co.	53, Newton Street, Birmingham	"Walco," Birmingham	Central 3305
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261	Wilkinson, Thos., & Co., Ltd.	Middlesbrough	Blacking, Middlesbro'	419
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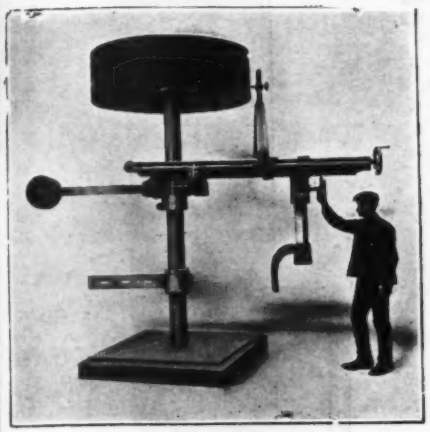

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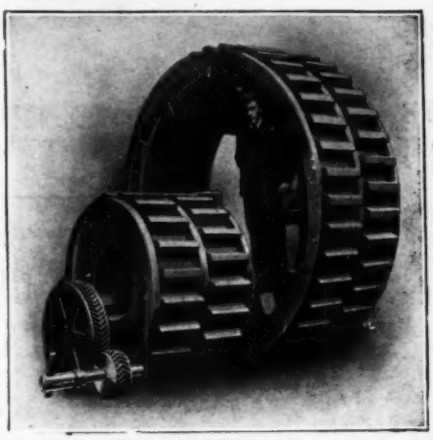

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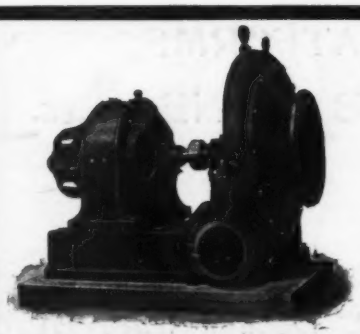

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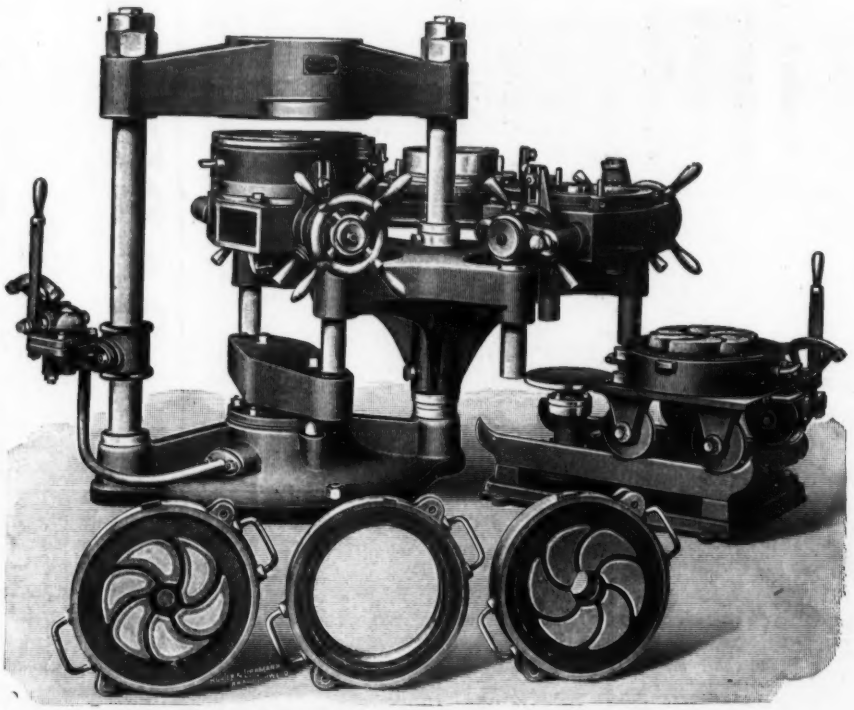

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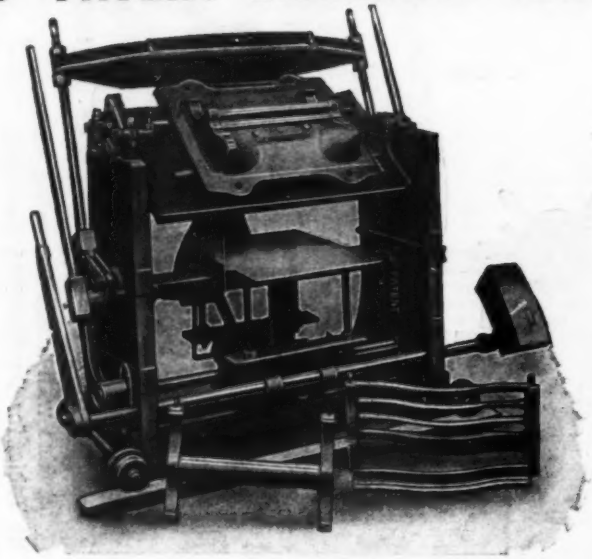

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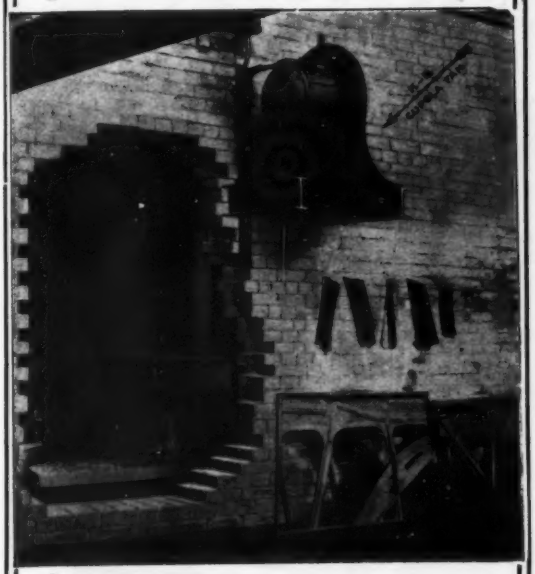

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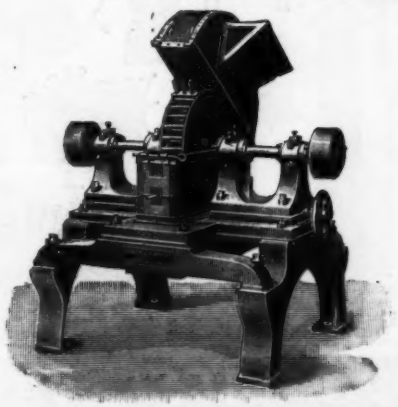

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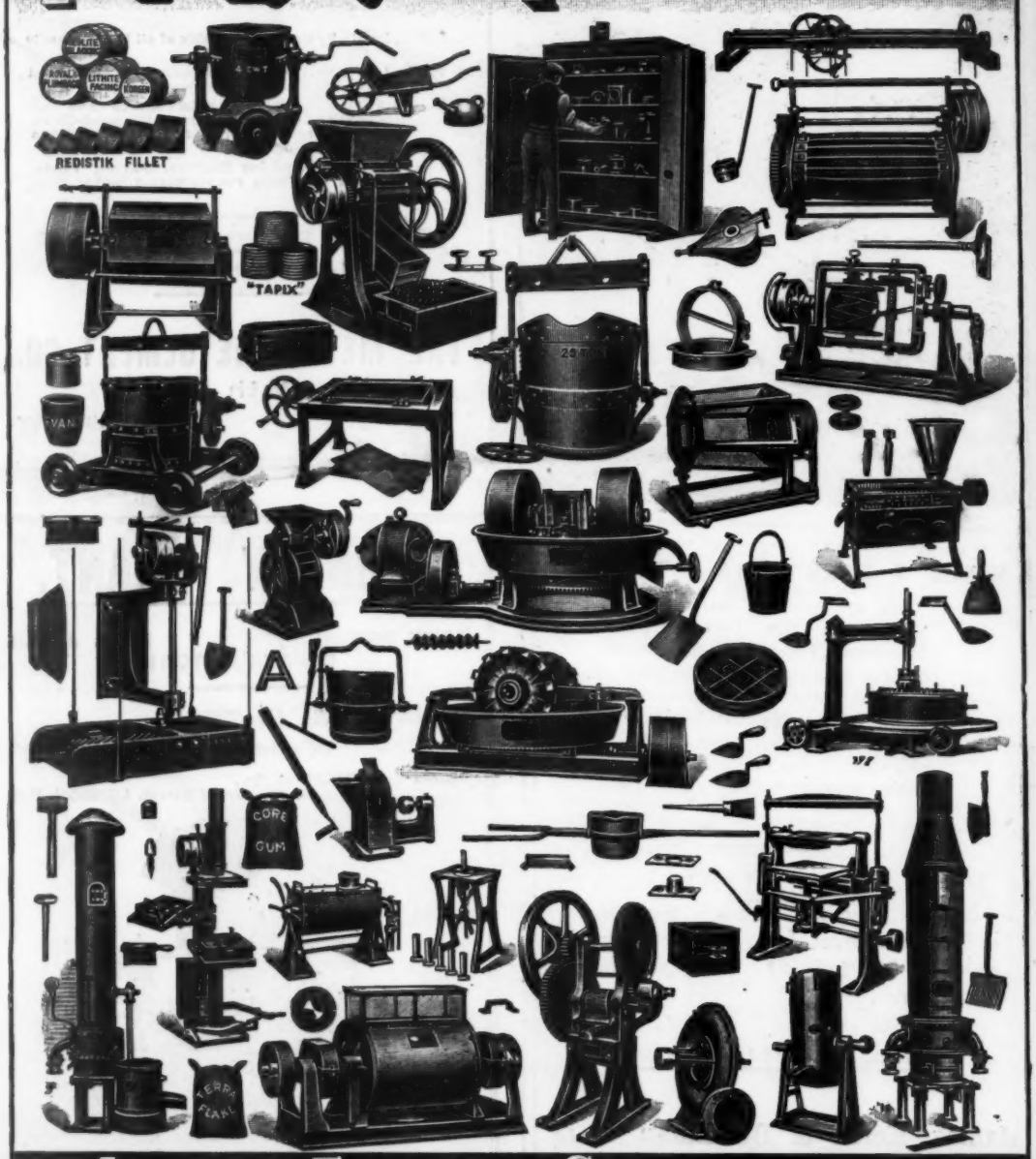
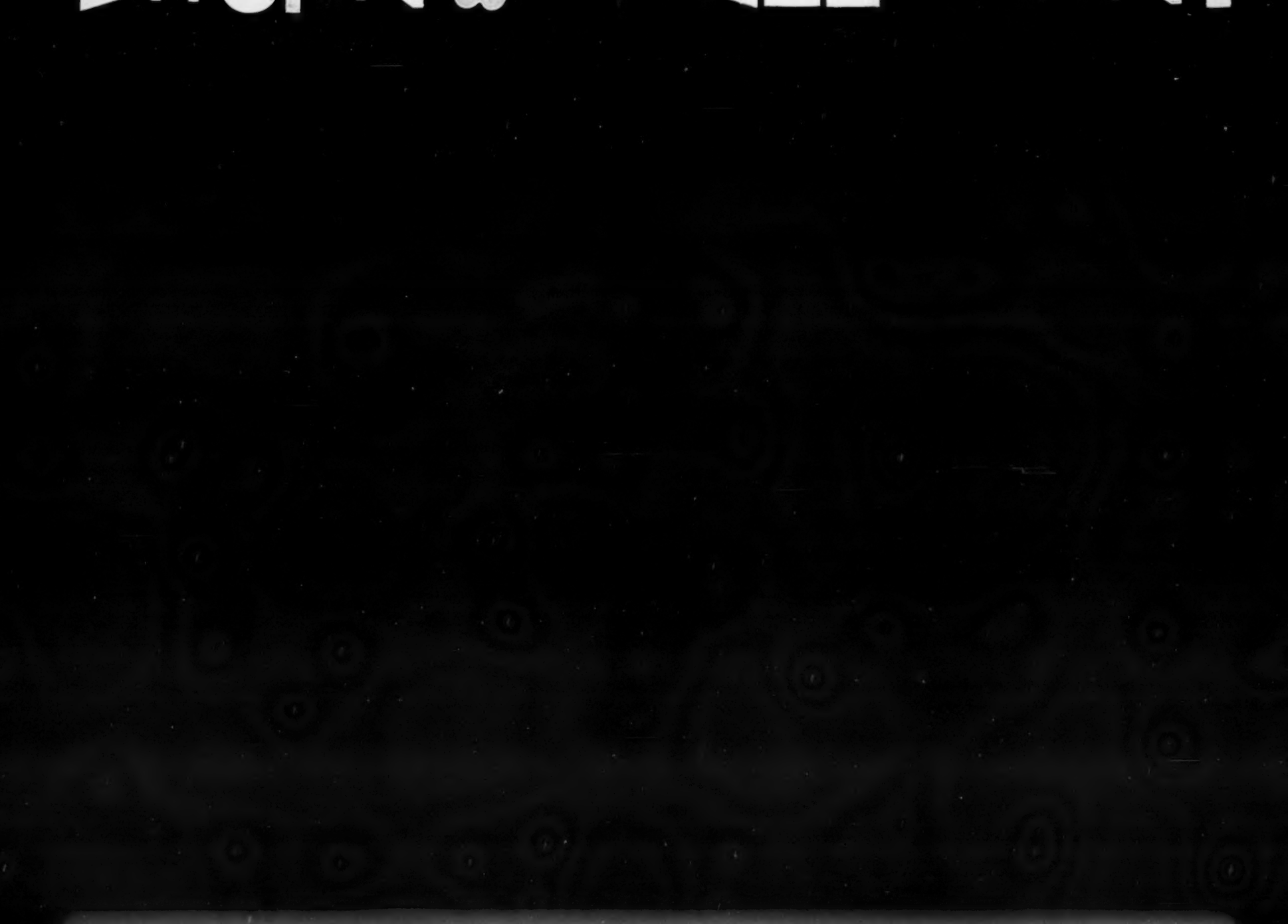
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